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**BARRICK RESOURCES (USA), INC.**
**MERCUR MINE PRELIMINARY**
**TAILINGS IMPOUNDMENT CLOSURE PLAN**

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Prepared for:


Barrick Resources (USA), Inc.
P.O. Box 838
Tooele, Utah 84074


Prepared by:


JBR Consultants Group
8160 S. Highland Drive
Sandy, Utah 84093

# BARRICK MERCUR MINE PRELIMINARY TAILINGS IMPOUNDMENT CLOSURE PLAN

## Executive Summary

Upon cessation of ore processing, the Reservation Canyon Tailings Impoundment will contain approximately 25 million tons (Mt) or 22 million cubic yards (Mcy) of tailings. The tailings surface will cover approximately 90 acres. It is the intent of Barrick Resources (USA), Inc., to close this facility in an orderly and deliberate manner. This will ensure protection of public health and safety. It will also ensure compliance with the statutes, regulations, and permits which pertain to the construction, operation, and closure of the facility. Closure in this use includes final reclamation and revegetation of the impoundment.

This closure plan reviews the pertinent regulatory objectives of the agencies which jointly govern the facility. These agencies are:

Utah Division of Water Quality
Utah Division of Water Rights
Utah Division of Oil, Gas and Mining
Utah Division of Air Quality
Bureau of Land Management

The past, present, and future configurations of the facility are reviewed, including the physical and chemical characteristics of the tails. The salient characteristics of the site geology, hydrology, soils, and vegetation are presented in support for the design objectives of the plan.

The design objectives ensure protection of public health and safety. Both surface and ground water quality are protected by existing and proposed designs. The structural stability of the impoundment and its embankments are and will be assured for agents ranging from erosion to significant seismic events. Fugitive dust is and will continue to be controlled through the final closure. The area is designed to ultimately return to wildlife use.

The final closure is proposed to include evaporative dewatering of the tailings impoundment followed by two years of consolidation. During the dewatering/consolidation phase, preliminary vegetation would be introduced on the tailings surface. Upon development of a dry surface which will support construction, the tailings would be contoured for flood routing compliance. Following that, a 12-inch thick topsoil layer would be placed over the entire tailings surface. This would be revegetated with a final reclamation seed mix.

The final closure step would be the construction of a flood discharge spillway. This would avoid erosion and ensure protection of the dam and buttress faces as well as the contained tailings. In addition, it would minimize storm water ponding in the historical basin, minimizing rewetting of the enclosed tailings.

Following closure, monitoring would continue in accordance with applicable permit requirements.

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## 1.0 Background

In compliance with the terms of Ground Water Discharge Permit No. UGW 450002, Barrick Resources (USA), Inc. (Barrick) has prepared this conceptual plan for closure of its Mercur Mine tailings facility for review and approval by the Division of Water Quality. The Mercur tailings impoundment was originally permitted in 1981. The former owner of the facility, Getty Mining Company, also obtained the following permits for tailings impoundment: a Permit to Construct from the (then) Utah Bureau of Water Pollution Control, approval of a Notice of Intent and Reclamation Plan from the Division of Oil Gas and Mining (Permit No. ACT/045/017), approval of a Plan of Operations from the U.S. Bureau of Land Management (Permit No. U027), a National Pollutant Discharge Elimination System permit from the Environmental Protection Agency, a Construction Permit from the Utah Division of Water Rights, Dam Safety Office, and other necessary State and Local permits. All permits previously acquired by Getty were transferred in their entirety to Barrick Resources (USA), Inc.

tailings plans were never approved previously, (reclamation plan)

## 1.1 Location

The Mercur mine and mill are located in Mercur Canyon in the Oquirrh Mountains, 35 miles southwest of Salt Lake City, Utah (Figure 1). The tailings impoundment is located in Section 5, Township 6 South, Range 3 West, Salt Lake Base and Meridian (Figure 2).

## 1.2 Regulatory Objectives

The final closure plan for the Mercur tailings impoundment must meet the applicable regulations and conditions of permits issued to Barrick by the following regulatory agencies: the Utah Division of Water Quality (DWQ), the Utah Division of Oil Gas and Mining (DOGM), the Utah Division of Water Rights, State Engineer, the United States Bureau of Land Management (BLM), and the Utah Division of Air Quality (DAQ). The regulatory objectives set forth in the permits issued by these agencies are described below.

### 1.2.1 Utah Division of Water Quality

The DWQ has regulatory authority over the Mercur tailings impoundment through three principal permits: the construction permit for the tailings impoundment, originally issued on May 21, 1982 and subsequently modified June 5, 1992; Ground Water Discharge Permit UGW

450002, issued on June 5, 1992; and UPDES Permit UT-0023884, originally issued in 1982, revised in 1983, and renewed in 1988 and 1992.

The DWQ has classified most ground water at Mercur as Class II under the Utah Ground Water Protection Regulations. In accordance with this classification, the protection levels described in Table I of the Ground Water Discharge Permit for five of seven monitoring wells have been established (see Section 2.3.3 for a copy of Table I). The five monitoring wells are TMW-1, TMW-2, MW-8, MW-15, MW-16, MW-17 and MW-18. According to the Utah Ground Water Quality Protection Regulations, ground water concentrations of the monitored parameters at these locations should remain at or below the protection levels or a condition of potential non-compliance would exist. This compliance requirement is assumed to extend past the closure of the tailings facility into a currently undefined post-closure period. Thus the closure planning for the facility should include technical provisions to allow the facility to continue to meet the protection levels as well as provide for continued ground water compliance monitoring for a reasonable period of time following closure.

The permit requires that the tailings facility be operated and maintained to "prevent any spills, leakage or overflow from contact with unlined ground surfaces, ground water or surface runoff conveyance systems (ditches, streams, etc.)". The tailings impoundment is also required by the permit to contain 1/2 the Probable Maximum Precipitation in the drainage basin and 1.5 times the maximum wave height. The design for the closure of the facility should be such that the above permit conditions can be complied with.

According to Part I.A.3. of the permit, a Conceptual Closure Plan should be submitted within 1 year of the permit date. This date was subsequently extended to December 5, 1993. The permit does not contain details as to the required content of this conceptual closure plan.

The Mercur UPDES permit currently has five permitted outfalls, including three associated with the tailings impoundment. These are outfall 003 which is the tailings basin itself and outfalls 007 and 008 which are the lined chimney drain catchment ponds located below the main dam and the saddle dam of the tailings impoundment. The UPDES permit states that "there shall be no discharge from the (tailings impoundment) outfalls".

Discharge is allowed by the permit from the non-tailings impoundment outfalls, if the water quality of the discharge complies with the effluent limitations of the permit. These limitations would also apply to an unavoidable discharge from the tailings impoundment outfalls. Table 1.2.1 shows the effluent discharge limitations allowed in the UPDES permit.

**Table 1.2.1 Barrick Mercur UPDES Permit Effluent Limitations**

| Characteristics | Effluent Discharge Limitations (mg/l) | |
|---|---|---|
| | 30-Day Average | Daily Maximum |
| Suspended Solids | 20 | 30 |
| Oil and Grease | N/A | 10 |
| Total Copper | 0.15 | 0.30 |
| Total Mercury | 0.001 | 0.002 |
| Total Lead | N/A | 0.3 |
| Total Cadmium | N/A | 0.05 |
| Total Zinc | N/A | 0.75 |
| Total Cyanide | 0.1 | 0.2 |

Because the effluent limitations apply only to active mining operations, it could be assumed that this no-discharge requirement applies only to process water and mixtures of runoff and process water from the operating tailings pond. Following reclamation of the tailings facility, discharge of runoff only (no process water) from the tailings impoundment would occur. A revision of the UPDES permit for the post-closure period when this additional outfall would occur, may be necessary. It may be that the storm water runoff requirements of the UPDES rules would then apply to all outfalls at the Mercur property, at least until the reclamation bond with the DOGM is released. This will need to be clarified with the DWQ.

- will bond amount change based on new tailings rec. proposal?

### 1.2.2 Utah Division of Oil, Gas and Mining

- when?

The Barrick reclamation plan, approved by the DOGM, states that the tailings impoundment would be reclaimed by: removing all pumps and piping, allowing the surface to dry, topsoiling the tailings surface with 12 inches of topsoil, and revegetating the topsoil with the "North-East" revegetation mixture. The "North and East Aspects" revegetation seed mixture is contained in Table 2.4-2a of the permit which is included in the appendix to this closure plan. The face of the original main and saddle dams would not be regraded or topsoiled but would be revegetated by hydroseeding. This lack of a topsoiling requirement or seeding of the modified tailings dam as part of the final reclamation is in recognition that Barrick will have already revegetated the original dam face as part of the operations.

The approved reclamation plan does not require regrading of the tailings facility. The runoff management plan in the reclamation plan indicates that the tailings impoundment would continue to contain the runoff from its upland watershed in the post-reclamation period. This condition contradicts the current closure requirements of the Division of Water Rights with regard to closure of dams and impoundments. - good point

### 1.2.3 Division of Water Rights - Dam Safety

According to Part R625-11-11 of the Utah administrative rules for dam safety, the Utah State Engineer has the approval authority over abandonment of dams in the State. These regulations apply to either removal or breaching of a dam. In the case of this closure plan for the Mercur tailings impoundment, the regulations for breaching a dam would apply and the applicable design criteria are as follows:

1) The flowline of the breach should be excavated down to natural ground or to the top of the silt level. Grade control and drop structures may be required to prevent mobilization of reservoir silts and debris.

2) The breach should be designed to pass a flood with a return period of 100 years without backing water up in the historic reservoir more than 5 feet.

3) Regardless of hydraulic requirements, the bottom width of the breach should be one half the structural height of the dam with an absolute minimum of 10 feet.

4) Breach side slopes must be flat enough to hold the slope when saturated, with an absolute minimum of 1v:1h. In areas where there is significant human travel, the minimum side slopes should be 1v:2h.

5) The exposed banks and bottom of the breach should be protected with riprap, vegetation, or other suitable means to prevent downcutting and lateral slope erosion.

6) Barriers should be placed on the original dam crest to warn any possible traffic on the crest of the breach.

In addition to the final breaching of the dam, the State Engineer has indicated that a spillway must be added to the impoundment. The spillway design must comply with the dam safety regulations and the applicable criteria.

### 1.2.4 U.S. Bureau of Land Management

Barrick's current reclamation obligations to the BLM and described in the current approved Plan of Operations are the same as those described in the DOGM NOI.

In September of 1991 the Utah State Office of the BLM published a Draft Cyanide Management Policy which addresses design, operation, and closure of cyanide heap leach and mill tailings operations. These draft standards were circulated for public comment and have not yet been issued in final form. The intent of the plan was to provide guidance to mine operators and the BLM staff for the development of mining projects in concert with best management practices, avoiding unnecessary and undue degradation of Federal lands, and preventing adverse off-site impacts.

The introduction to the draft plan document indicated that these requirements would apply to all new mining notices and plans of operations. Existing plans or operations, would not be required to retrofit to conform to the standards unless one of the following exceptions applies:

1) An unauthorized discharge has occurred and designed overflow containment facilities are determined to be inadequate by the authorized officer.

2) If avian mortalities have been experienced, then netting of existing lethal solutions containment structures will be required.

3) Reconstruction of heaps, pads, and cyanide solution ponds, if such facilities are causing unnecessary or undue environmental degradation.

The draft policy does not apply as regulation to the Mercur tailings impoundment at the present time because it has not been finalized. When the final version of the plan is promulgated, it is unclear whether or not it would apply to Mercur because of Mercur's status as an existing facility. At the present time, it is Barrick's assertion that none of the exceptions listed above apply to the Mercur tailings facility.

Certain components of the original draft of these regulations addressed closure of tailings impoundments. These are summarized as follows:

1) Tailings impoundments would be left non-impounding and the tailings solids dewatered.

2) Dewatering effluent would be required to contain less than 0.22 mg/l weak acid dissociable cyanide (WAD), have a pH of from 6 to 9 and meet the Federal Drinking Water Maximum Contaminant Levels (MCL's) or appropriate State Standards for metals.

OMITTED WORD - CYANIDE?

3) Detoxification of tailings would be required upon closure. The detoxification standards for would be the same as those for dewatering. The detoxification may be accomplished by natural means, water rinsing, or active chemical treatment.

4) Sampling of tailings solids may be necessary to evaluate the residual cyanide and metal content and the potential for releases.

5) Capping of tailings impoundments with low permeability material may be required where tailings are difficult to detoxify and represent a substantial environmental threat.

6) Reshaping of the tailings surface would be required to eliminate collection of precipitation.

7) Tailings impoundments, including dams, would have to be regraded to maximum slopes of 3h:1v and grades should be sufficient to allow topsoil replacement, vegetation reestablishment and to prevent erosion.

8) Tailings impoundment liners would have to be perforated, or the containment dike breached following detoxification to prevent solution build up in the reclaimed impoundment.

9) Post-reclamation surface water diversion channels would have to contain at a minimum the 100-year, 24-hour storm . The probable maximum flood (PMF) would also be considered as a design criterion for channels, depending on site-specific conditions.

10) Monitoring of tailings leachate (if applicable) would be required at a pre-established collection point for a post-reclamation monitoring period of at least 5 years.

Barrick is on record with the BLM as opposing tailings detoxification requirements, the proposed detoxification standards, regrading of tailings facilities (especially as regards regarding of tailings impoundments), and perforation of tailings impoundment liners. Barrick supports dewatering of tailing impoundments to the extent necessary to achieve reclamation and facilities closure.

### 1.2.5 Utah Division of Air Quality

The current DAQ permit for Mercur requires control of fugitive dust from disturbed areas. It is assumed that fugitive dust will need to be controlled from the reclaimed tailings pond to comply with UDAQ air quality regulations.

## 2.1 Tailings Facility Description

### 2.1.1 Past Configuration and Operations

The Barrick Mercur tailings facility was constructed in 1982 by Getty Mining Company. Its design included the construction of a main dam across Reservation Canyon and a saddle dam across a low saddle between Reservation Canyon and Manning Canyon (Figure 3). The design called for construction of zoned, earth-fill embankments constructed from borrow material obtained from on site and select drainage material imported from off site (Figure 4). The main downstream and upstream shells of the dams were constructed with limestone rock borrowed from on site. Clay cores were built within these shells constructed of Manning Canyon shale locally borrowed. Inclined drains were constructed downstream of the clay cores and these were built out of select permeable sand and gravel brought in from off site. The drainage systems were connected with pipes to seepage reclaim ponds located near the downstream toes of the dams.

The original dams were intended to be raised in a downstream construction manner in three stages until the tops of both embankments reached an elevation of 7,260 feet. The maximum tailings capacity at this tailings elevation was 9,800,000 cubic yards.

To minimize seepage from the tailings impoundment, a clay liner was built under the tailings impoundment area. This liner consisted of two, compacted, 6-inch lifts of Manning Canyon shale material. The lower lift was mixed with bentonite to reduce its compacted permeability. The design permeability of the bentonite-amended liner was 1 x $10^{-7}$ cm/sec which was verified in the field with quality control procedures. This liner was tied into the clay cores of the dams and was extended upward in the impoundment area in stages along with the lifts on the embankments.

Tailings were conventionally discharged to the facility from one or more points around the impoundment between startup in April, 1983 to September, 1987. This produced a relatively homogeneous deposit of tailings solids up to an elevation of approximately 7,213 feet. In 1987, tailings discharge was converted to a subaerial method wherein tailings discharged from many points along the main dam to form a beach of sand. This method of discharge was used to develop greater unit weights for the tailings which would extend the useful life of the facility. The sand deposited on the beach provided a better foundation material for planned future upstream construction of the main dam.

Water is recycled from the impoundment for use in the mill with two barge-mounted submersible pumps with a combined capacity of approximately 1,800 gpm.

The tailings capacity of the original design was reached in 1992.

### 2.1.2 Present Configuration and Operations

The design of the tailings facility was changed in 1989 to increase the capacity to 20,500,000 cubic yards of tailings. The design of the embankments was revised to utilize an upstream construction method for future raises. This method involves construction of a series of lifts for a containment buttress made out of quarried limestone (Figure 4). Each buttress lift is constructed partially on top of the previous lift and partially on top of the tailings beach. In this manner, the overall buttress is built upstream over previously deposited tailings.

Mill tailings, prior to being pumped to the tailings impoundment, pass through an INCO $SO_2/O_2$ chemical treatment system to destroy the cyanide content of the tailings slurry. The typical total cyanide content of the treated tailings is less than 5 mg/l. Subaerial deposition of the treated tailings is continued from the upstream face of the buttress.

The saddle dam height was not raised above elevation 7,250 feet. Instead, a new levee made of coarse rock was built inside the impoundment upstream from the saddle dam. This levee has served as the foundation for the upstream construction buttress. The area between the saddle dam and the buttress was converted for use as a seepage reclaim cell.

The levee and the buttress are made of quarried, unmineralized limestone and are intended to be free draining. Seepage of tailings water through the buttress along the main dam is collected at the downstream toe of the buttress and collected in a sump where it is returned to the tailings impoundment. At the buttress abutments, a 24-inch thick, cutoff wall extends under the rock fill to provide positive seepage containment. Seepage through the levee is collected between the levee and the saddle dam and also returned to the tailings impoundment.

Water from the tailings impoundment is recycled to the mill from pumps located within the northeast portion of the impoundment area. These barge-mounted pumps also reclaim tailings impoundment water for use in the dump leach.

The impoundment liner has been increased in area as the impoundment has grown and the liner design has been modified over time to its current composite structure. The foundation for the liner is compacted earth which is then covered with a minimum of 12 inches of screened and compacted Long Trail clay. The compacted clay must achieve a field-verified permeability of $1.0 \times 10^{-7}$ cm/sec. The clay layer is covered with an earth moisture barrier, nominally 4 to 6 inches thick. The final component of the liner is a geotextile cover for erosion protection.

The liner is installed on a slope no steeper than 3h:1v. This slope is achieved by grading as necessary before placement of the liner.

The current (1993) elevation of the top of the buttress is 7305 feet. The tailings elevation is approximately 7284 feet and the tailings cover approximately 80 acres. The present tailings discharge rate is approximately 5,000 dry tons per day of solids and 8,000 tons per day of solution.

### 2.1.3 Future Configuration and Operations

The future configuration of the tailings facility is subject to the changing production requirements of the Mercur operation. The following is a reasonable prediction of the configuration of the facility at the time of closure but the reader should be aware that changes to this description are likely to be made in the future. Such changes are more likely to be in the final elevations of the various components of the tailings facility rather than in its overall layout, design, or method of operation.

The maximum design elevation for the tailings dam buttress will be 7,360 feet which conforms to the expected annual tailings surface rise of 15 feet per year. This is a conservative design which will provide a 13-foot apparent freeboard over the expected maximum tailings elevation of 7,347 feet. At this elevation, the tailings will cover approximately 90 acres (Figure 5). Using current projections, the tailings surface and buttress would reach their maximum elevations in 1999, unless further changes in design and permitted capacity are made, the discharge of tailings would then cease.

At the time of closure, the original main tailings dam would have a 2h:1v slope from its toe to the top of the original dam at an elevation of 7250 feet where a 50-foot wide bench or road would exist (Figure 4). This slope will have been revegetated by the time the tailings facility is closed. A seepage collection apron for the buttress is present at the downstream toe of the buttress. The exposed downstream buttress face will extend from the bench at a 2h:1v slope to the final elevation of 7360 feet where the top of the buttress will be 50-feet wide.

Also at the time of closure, the top of the saddle dam will remain at its current elevation of 7250 feet. Approximately 200 feet north of the saddle dam will be the outer face of the levee buttress, which will extend up a 2h:1v slope to a final elevation of 7360 where there will be a 50-foot wide roadway. A ramp along the outer face of the buttress in this area will slope down the buttress face from the east to the west at a 5 percent slope where it will connect with the site access road.

The roadway along the top of the buttress will also connect with a road around the north and east side of the tailings impoundment, at the edge of the liner. This road will be at an elevation of 7360 feet and will be 30-feet wide. At the outer edge of this road will be the toe of a cut into the natural slope which will be at a cut slope of about 1h:1v in rock and 1.5h:1v in unconsolidated materials. This cut will vary in height up to about 70 feet.

As a result of the subaerial tailings deposition method, the tailings solids along the upstream face of the buttress will form a sandy beach approximately 300 feet wide sloping toward the center of the impoundment. This beach will grade toward the interior portion of the tailings impoundment area where the tailings will then consist primarily of silt and clay. The elevation of the solids surface in the impoundment area furthest from the beach is expected to be approximately 15 feet lower than the top of the beach.

Following cessation of mill operations, the tailings water reclaim system may continue to operate removing water for use in one of the valley fill leach operations. Water that is not pumped from the impoundment area would evaporate. The seepage reclaim pumps located at the main dam and at the saddle dam would continue to pump the seepage water back to the tailings impoundment as long as required.

$\infty$ ?

## 2.2 Tailings Characteristics

### 2.2.1 Physical Characteristics

The tailing waste material consists of finely ground ore following leaching with cyanide and subsequent treatment in the INCO system to reduce the cyanide concentrations. The nominal gradation of the tailings is approximately 85 percent minus 200 mesh by weight.

The tailings are discharged to the tailings facility as a slurry of 34 to 38 percent solids by weight. The solids settle out of the slurry after discharge to the impoundment. The initial dry unit weight of the subaerial tailings solids is approximately 94 pounds per cubic foot (PCF) (Physical Resource Engineering, 1993a). As additional solids are deposited, previously deposited solids are consolidated by the overburden pressure. The rate of consolidation is controlled by the rate at which the contained water can drain out of the solids. Further consolidation may occur with additional burial, and tailings solids near the bottom of the impoundment may have a unit weight approaching 100 PCF.

The tailings have medium horizontal permeability despite their fine grained nature and the contained clay minerals. The permeability of the subaerial tailings solids is approximately $2 \times 10^{-3}$ cm/sec (Physical Resource Engineering, 1993b). The permeability of the older tailings deposited below an elevation of about 7210 feet may be marginally lower as they are less sorted than the sub-aerial tailings.

The strength properties of the tailings differ slightly between the older, deeper tailings solids and the newer tailings deposited nearer the surface. Laboratory testing of samples of the deeper tailings indicate no measured cohesion and a friction angle of 30 degrees (Physical Resource Engineering, 1989). The subaerial tailings have a cohesion of 42 pounds per square foot (PSF) and a friction angle of 33 degrees (Physical Resource Engineering, 1993a).

Following cessation of operations, the tailings will begin to dry from top down. This desiccation will reduce the water content of the tailings solids and tend to enhance their consolidation, particularly with the clayey solids. As these solids desiccate, their dry unit weights are expected to increase as will their strength properties. As the clayey materials desiccate, their bulk permeabilities are expected to decrease although desiccation cracks having high permeabilities may also form. The dried clay materials are expected to form a solid surface which may be covered with a salt crust.

The sandy materials are not expected to consolidate or crack as they desiccate. The strengths and permeabilities of these materials are also not expected to change with time.

The dry surface area of the tailings deposit is expected to have different gradation depending on proximity to the tailings discharge points. The beach area directly under the discharge points, and for a distance of approximately 300 feet down slope, is expected to be covered with fine sand and silty sand. Further into the tailings impoundment, these deposits are expected to grade into silts and clayey silts. These silts would then grade into clays at the farthest distance from the discharge points.

The load bearing strength of the tailings will vary with the type of material. The moist to dry sands and sandy silts will have the highest bearing strengths and are expected to be able to support light-weight, low-ground-pressure, tracked mechanical equipment. The silts, clayey silts and the clays are expected to have poor bearing strengths, particularly when they are moist and are not expected to be able to directly support any mechanical equipment. The silts are expected to provide only marginal bearing strengths when dry because of their lack of cohesion and under-consolidation. The clayey silts and clays are expected to provide adequate bearing strength for low-ground-pressure, tracked equipment when dry because of their cohesion, however this strength would be adversely affected by rewetting the tailings from precipitation.

### 2.2.2 Chemical Characteristics

The Mercur mill tailings are currently being treated to reduce their cyanide content. This treatment began in February, 1992. Prior to initiation of treatment, water in the tailings impoundment had a total cyanide content of about 40 mg/l. Currently the treated tailings have total cyanide values averaging only 1.34 mg/l. Water is reclaimed from the impoundment for reuse in the heap leach facilities and in the mill.

The dominant dissolved constituents in the tailings effluent are sulfate, carbonate complexes, and calcium and sodium. Secondary constituents are ammonia, bicarbonate, chloride, magnesium, and nitrate. Trace constituents comprise the remainder. Barrick and Getty Mining Company have been analyzing the tailings reclaim water chemistry since 1983. These data, along with tailings effluent data collected since the cyanide treatment facility was installed, have been reviewed for any changes in chemical characteristics. Table 2.2-1 presents the mean concentrations of tailings constituents which exceed Utah Ground Water Quality Standards. The ground water quality standards for barium, cadmium, chromium, copper, lead, silver, and zinc were not approached by the concentrations of these metals in the tailings effluent or reclaim water either before or after the initiation of treatment for cyanide destruction. Those contaminants that occur in concentrations well below the ground water quality standards are unlikely to adversely affect ground water quality and are therefore not listed in Table 2.2-1.

**Table 2.2-1 Mean Concentrations of Tailings Water Analytes Exceeding Utah Ground Water Quality Standards (mg/l)**

| Parameter | G.W.Standard | Tailings Reclaim 7/83 - 1/92 | Tailings Reclaim 4/92 - 1/93 |
|---|---|---|---|
| Arsenic | 0.05 | 1.06 | 1.09 |
| Cyanide | 0.2 | 72.5 | 0.584 |
| Fluoride | 2.4 | 2.67 | 1.85 |
| Mercury | 0.002 | 0.02 | 0.028 |
| Nitrate | 10.0 | 15.50 | 48.55 |
| Nitrite | 1.0* | 0.85 | 3.46 |
| Selenium | 0.05 | 0.04 | 0.642 |
| Sulfate | 500.0* | 2024 | 2636 |
| Thallium | none | 0.07 | 0.238 |
| TDS** | 500 - 3000 | 3772 | 4583 |
| pH | 6.8-8.5 | 9.87 | 8.3 |

* - Proposed Standard
**TDS = Total Dissolved Solids - Ground Water Class Standard

mg $\Rightarrow 10^{-3}$ or 0.001g

Cyanide concentrations have been dramatically reduced with the destruction treatment. The concentration of dissolved mercury decreased after initiation of treatment; however, it remains an order of magnitude above the ground water quality standard. Fluoride concentrations decreased moderately to a level below the ground water quality standard following initiation of treatment. The mean pH of the effluent and reclaim water dropped to a level within the range established in the Utah Ground Water Quality Regulations for Class II ground waters.

The concentrations of selenium, sulfate, thallium, and TDS in the tailings reclaim water increased following commencement of treatment for cyanide destruction. Selenium concentrations increased by more than an order of magnitude, thallium concentrations doubled, TDS increased slightly more than 20 percent, and sulfate increased by approximately 30 percent. TDS and sulfate increases may be largely a direct result of the sulfur dioxide treatment. Selenium and thallium concentration increases may be a result of the cyanide detoxification and/or a change in ore chemistry itself.

The tailings solids consist of ground ore which has been leached with cyanide to remove the gold. The leached ore is discarded to the tailings impoundment and the chemistry of the tailings solids is therefore controlled by the original chemistry of the ore. Samples of tailings slurry were obtained from drop points in the tailings pond on July 12, 1993 and were analyzed for major and trace constituents. The average analyses for these samples are shown in Table 2.2-2.

**Table 2.2-2 Chemistry of 1993 Tailings Solids (mg/kg)**

| | | |
|---|---|---|
| Aluminum | 4,595 | |
| Ammonia | 13 | |
| Arsenic | 1,190 | – 75 mg/kg Ceiling Conc. Soils EPA |
| Barium | 3,390 | |
| Boron | 41 | |
| Cadmium | 5.4 | |
| Calcium | 46,300 | |
| Chloride | 54.5 | |
| Chromium | 14.5 | |
| EC (1:1 leach) | 1,905 | |
| Copper | 9.8 | |
| Total Cyanide | 0.4 | |
| WAD Cyanide | 0.1 | |
| Fluoride | 4.6 | |
| Gold | <1 | |
| Iron | 12,450 | |
| Lead | 2 | |
| Magnesium | 772.5 | |
| Manganese | 158 | |
| Mercury | 4.24 | |

**Table 2.2-2 Chemistry of 1993 Tailings Solids Continued (mg/kg)**

| | |
|---|---|
| Nickel | 14.1 |
| Nitrate | 6.2 |
| Phosphorous (P) | 0.4 |
| Potassium | 1,505 |
| Selenium | 2 |
| Silver | <1 |
| Sodium | 577 |
| Sulfate | 6,960 |
| Thallium | 33 |
| Zinc | 39.3 |
| pH | 9.1 |

[Avg. of Chemtech Lab# U097431 and U097432]

## 2.3 Ground Water Hydrology

### 2.3.1 General Geology

The tailings site is located in Reservation Canyon in the southern Oquirrh Mountain Range near the eastern edge of the Basin and Range physiographic province. Rocks in the immediate vicinity of Mercur consist of limestone and shale with some quartzite and intrusive igneous rocks. The rocks at Mercur are, from oldest to youngest, the Mississippian Humbug Formation (sandstone with interbeds of limy sandstone and dolomite), the Great Blue Limestone, also of Mississippian age (a lower and upper limestone member separated by the Long Trail Shale), the Mississippian/Pennsylvanian Manning Canyon Shale, the Pennsylvanian West Canyon Limestone Canyon (crystalline and argillaceous limestones with thin calcareous quartzite), and Quaternary deposits (silty clays, clayey gravels, and boulders).

The tailings impoundment is located approximately midway between the axes of two major, parallel, northwest-trending folds, the Ophir Anticline to the west and the Pole Canyon Syncline to the east. These broad, low amplitude folds are separated by the steeply dipping Manning Thrust fault, which moved the older Great Blue Limestone in an east-northeasterly direction and placed it, in the vicinity of the tailings impoundment over, but in near vertical contact with, the Manning Canyon Shale. At the tailings impoundment site the lower plate of the Manning Thrust, comprised of the Manning Canyon Shale and the West Canyon Limestone, underlies most of the site. The Manning Thrust and the Great Blue Limestone occur beneath the tailings dam. The lower plate has not been subjected to the high degree of normal faulting observed on the upper plate and has only sparse east-west to slightly northeast-trending, high angle normal faulting.

## 2.3.2 Ground Water Setting

The primary aquifers in the region are the unconsolidated deposits of Cedar and Rush Valleys. Fractured bedrock of the mountainous areas provides ground water recharge to the valleys. Although Paleozoic sedimentary rocks have low primary permeability, fracturing by several episodes of faulting and folding has caused the development of secondary permeability. It is also likely that some fractures and joints in the Paleozoic carbonate rocks have been enlarged by solution. The relatively impervious beds of the Manning Canyon Shale control the flow of ground water in the subsurface and the locations of springs. That part of the Oquirrh Mountains east of the Ophir Anticline, including the entire tailings impoundment site, is thought to provide recharge to the valley fill aquifer in Cedar Valley to the east of the mountains.

Ground water movement in the mountainous area in the vicinity of the site is controlled by major geologic structures and gravity. Regional ground water flow is down-dip northeasterly toward the southeast-plunging Pole Canyon Syncline, and then southeasterly toward Cedar Valley (Dames and Moore, 1991).

Water-bearing formations beneath the tailings facility include the unconsolidated deposits, the Manning Canyon Shale, and the West Canyon Limestone. These were investigated by Dames and Moore (1991) and the following hydrogeology discussion is derived from their report on these investigations.

A thin zone of perched ground water in the alluvial materials on top of the shale in Reservation Canyon was noted during early studies at the tailings impoundment site (Dames & Moore, 1982). Ground water was not encountered in any test pits or borings terminating in limestones. These unconsolidated clays, and clayey and silty gravels are considered heterogeneous. Tests performed in the alluvial materials resulted in permeability ranges from $6x10^{-7}$ to $9x10^{-3}$ cm/sec (Dames & Moore, 1982). Saturated thicknesses of the thin alluvial materials were small, on the order of several feet.

Porosity values of the silts and clays are generally higher than for coarser unconsolidated deposits. Porosities for clays, clayey and silty gravels may range from 35 to 70 percent (Freeze and Cherry, 1979). However, silts and clays display much lower hydraulic conductivities under saturated conditions due to the unconnected pore spaces. No water quality data are available for the alluvial perched zone.

Several small springs (seeps) in Reservation Canyon were noted prior to building the tailings facility. They occurred in the northwest area of the facility at elevations 7125 and 7230, in the lower argillite member of the Manning Canyon Shale. A second small spring was noted in the northeast area of the tailings between elevations 7215 and 7225 near the base of the West Canyon Limestone. These are now below the present tailings level.

The Manning Canyon formation is comprised mostly of shales and limestones. Ground water flow in the Manning Canyon Shale is in a fracture flow system. Ground water has been intercepted in the Medial Limestone unit in monitoring wells TMW-2 and MW-8 and within the underlying shale (argillite) and thinly bedded quartzite unit in MW-15. Well TMW-1 intercepts a saturated zone that extends from the transitional upper intercalated limestone-shale sequence to the base of the West Canyon Limestone. Interbedded shales may act as aquitards for locally perched ground water lenses. Wells MW-15, TMW-1 and TMW-2 indicate the aquifer is under variable degrees of confining conditions; whereas, responses from well tests in MW-8 suggest unconfined conditions.

Depth to ground water in TMW-1 was recently measured at approximately 105 feet. Depth to water in well MW-8 is approximately 288 feet. Ground water was first noted by the drillers in TMW-2 at about 630 feet during drilling and stabilized at the present static level of approximately 172 feet. MW-15 did not intercept water in the Medial Limestone during drilling. Water was first noted in the lower argillite at a depth of approximately 390 feet and then stabilized at a depth of nearly 216 feet. Saturated thicknesses are estimated to be on the order of less than five feet in MW-8 (as indicated from geophysical logs), as much as 60 feet (screened interval) in MW-15, 60 feet in TMW-1 and 160 feet in TMW-2 (sampling intervals).

Estimates of hydraulic conductivity for the wells were derived from single well tests and demonstrated a range of conductivities. Hydraulic conductivity was estimated at $4 \times 10^{-5}$ cm/sec in MW-8. For TMW-1, $1 \times 10^{-4}$ cm/sec was calculated from pumping. In TMW-2 $3.2 \times 10^{-5}$ cm/sec was calculated. A value of $4.3 \times 10^{-3}$ cm/sec was calculated for MW-15. The higher permeability exhibited at MW-15 is due to the higher number of fractures and brittle aspect of the formation at this location.

Packer tests in the unsaturated Manning Canyon shales (Dames & Moore, 1982) indicated permeabilities ranging from $2.9 \times 10^{-5}$ cm/sec to $1.9 \times 10^{-3}$. Porosity values in the shales are estimated to be in the range of zero to 10 percent while fractured limestones can range from zero to 20 percent and fractured quartzite from zero to 10 percent (Freeze and Cherry, 1979). The relatively high yields experienced from well MW-15 may be contributed through thin limestone or shaley limestone beds which are less ductile and more highly fractured than surrounding shale layers. The Medial Limestone section was dry at MW-15.

Monitor well MW-8 is completed into the top of the saturated zone as demonstrated by water levels and well testing. Water quality in MW-8 is likely more affected by nearby recharge at the outcrop. Ground water levels in MW-8 may be influenced by the effects of surrounding topography and that immediately to the south in Manning Canyon.

The West Canyon Limestone consists of limestones, shales, and quartzites. Monitor well MW-16 is completed in the West Canyon formation, with the screened interval placed below the first intercepted zone of saturation. Flow is in a fractured bedrock system where limestones predominate at the top of the section, and shales and quartzites become more predominant toward the base of the section. Geologic mapping has indicated that many joints are steeply dipping and normal to the axial trace of the Pole Canyon Syncline. The West Canyon Limestone is probably interconnected with Manning Canyon Shale and the shallow alluvial system via the fracture flow system.

Depth to ground water in MW-16 is approximately 430 feet. Saturated thickness is estimated to be the length of the screened interval, 60 feet. Ground water was first intercepted during drilling at 460 feet.

Hydraulic conductivity for MW-16 was estimated at 2.3 x $10^{-3}$ cm/sec from a single well test. Porosity can vary in a fractured limestone or calcareous quartzite depending on joint aperture width and spacing, and may range from zero to 20 percent (Freeze and Cherry, 1979).

Ground water movement in the area of the tailings impoundment is apparently easterly and possibly northeasterly in the downdip direction of the formations. Because wells installed around the tailings impoundment are screened in different hydrologic units and screen lengths vary, contouring the static water level data is inappropriate. However simple three-point calculations of piezometric levels, excluding MW-8, consistently indicate a northeast flow direction, in accordance with both the direction of dip and the major direction of jointing.

### 2.3.3 Ground Water Chemistry

The baseline ground water quality data have been collected for all monitoring wells around the tailings impoundment, including TMW-1, TMW-2, MW-8, MW-15, MW-16, MW-17 and MW-18. Total dissolved solids concentrations in samples taken from all seven monitor wells fall within the range of 500 to 3000 mg/l, which defines the range of TDS for Class II ground waters under Utah's Ground Water Protection Regulations. Low concentrations of total cyanide, commonly an order of magnitude or more below the ground water protection level, are ubiquitous in most wells. The dissolved constituents of the ground water are bicarbonate, calcium, chloride, magnesium, silica, sodium, sulfate, and trace concentrations of heavy metals (Table 2.3.3).

The results of compliance monitoring conducted subsequent to the establishment of protection levels for the seven wells has revealed that for nearly all parameters, detectable concentrations are well below the established protection levels. The principal exception to this generalization is selenium, which is found at levels in excess of the protection levels in one or more samples in wells TMW-1, MW-8, MW-15, MW-16, MW-17 and MW-18.

**Table 2.3.3 Monitoring Well Background Water Chemistry** (mg/l)

| | Well Number | | | | | | |
|---|---|---|---|---|---|---|---|
| | TMW-1 | TMW-2 | MW-8 | MW-15 | MW-16 | MW-17 | MW-18 |
| pH (units | 8.08 | 7.98 | 7.64 | 7.70 | 7.82 | 7.44 | 7.37 |
| Arsenic | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Barium | 0.066 | 0.050 | 0.071 | 0.071 | 0.054 | 0.051 | 0.067 |
| Cadmium | <.002 | <.002 | <.002 | <.002 | <.002 | <.002 | <.002 |
| Chromium | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Copper | 0.011 | 0.016 | 0.016 | 0.25 | <.01 | <.01 | <.01 |
| Lead | <.005 | <.005 | <.005 | <.005 | <.005 | <.005 | <.005 |
| Mercury | <.0002 | <.0002 | <.0002 | <.0002 | <.0002 | <.0002 | <.0002 |
| Nickel | <.01 | <.01 | 0.016 | <.01 | <.01 | <.01 | 0.017 |
| Selenium | <.002 | <.002 | <.002 | <.002 | <.002 | 0.0027 | 0.0029 |
| Silver | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Zinc | 0.02 | 0.013 | 0.049 | <.01 | 0.014 | 0.055 | 0.028 |
| Cyanide (T) | 0.0023 | 0.0025 | <.002 | 0.0034 | 0.038 | 0.0022 | 0.0052 |
| Fluoride | 1.93 | 0.98 | 0.26 | 0.307 | 0.258 | 0.152 | 0.178 |
| Sulfate | 54.3 | 301 | 90.1 | 235 | 307 | 34.6 | 181.9 |
| TDS | 516 | 910 | 970 | 994 | 883 | 344 | 654 |

[Refs. Table 1, 6/5/92 Ground Water Quality Discharge Permit, and Tables 1 and 2, Dames and Moore, 7/12/93]

## 2.4 Soils

The soils in the vicinity of the tailings impoundment were described in the Barrick NOI which was approved by the DOGM. The soils that existed in the foot print of the tailings impoundment prior to its construction were largely variant loams and clay loams of the Acord and Ant Flat soil series. Those topsoils that were salvageable for later reapplication during reclamation have been salvaged and are available in stockpiles around the tailings impoundment. Continued enlargement of the tailings impoundment will result in disturbance of areas covered with these same soils types. Salvageable topsoil will continue to be recovered and stockpiled as the impoundment is enlarged.

## 2.5 Vegetation

The native vegetation at the site of the tailings impoundment is described in the DOGM NOI as Mixed Brush Community, dominated by dense overstory stands of gambel oak, mountain mahogany, and Utah serviceberry interspersed with big sagebrush and understory species including snowberry, bluegrass and wheatgrass (JBR, 1986). In the higher elevations in the Oqquirhs, aspen occurs as scattered groves. DOGM regulations require that unless a variance is granted, this vegetative community be re-established on the reclaimed tailings surface. Accordingly, the reclamation plan in the DOGM NOI calls for the application of a diverse seed mix of native grasses, forbs and shrubs following topsoiling. This seed mix is described in the DOGM reclamation plan as the Mixed Brush Sites, North and East Aspects seed mix.

## 2.6 Surface Water Hydrology

The Mercur Mine is located on the west side of the Oqquirh Mountains. The tailings impoundment is located within Reservation Canyon which is a tributary to the main Mercur Canyon watershed. All the drainage channels of the Mercur Canyon watershed are ephemeral and sustain flow only in response to runoff from spring snowmelt and large spring and summer storms. The surrounding topography consists of steep mountain terrain with slopes ranging from 5 to 50 percent. The ground surface consists of either bare limestone outcrop or varying thicknesses of soil. The soil is generally thin but can reach significant thicknesses in drainage bottoms. The types of soils at Mercur are either Soils Group C or D by the SCS (NEH-4).

~5°-27°

The vegetation cover of the Reservation Canyon watershed is typically about 50 to 69%. The land use is considered to be native range and is not heavily grazed. The SCS hydrologic grading is Fair (SCS, NEH-4).

The drainage basin area for Reservation Canyon upstream of the tailings embankments is approximately 740 acres. This area has been reduced to 542 acres by construction of a diversion ditch which intercepts runoff from above the tailings impoundment and diverts it north into Meadow Canyon. This diversion channel is triangular in cross section and is approximately 15 feet wide and 3 feet deep. Although significant in size and capacity, it is not considered to be a permanent feature for closure so it is assumed that the runoff from the entire upland watershed would eventually be discharged onto the tailings impoundment area after closure. – not a good idea

The Curve Number technique of the Soil Conservation Service has been used to estimate the runoff from the Reservation Canyon watershed above the main tailings dam. For the post-reclamation period, two inflow events were modeled: the 100-year, 24-hour storm and the Probable Maximum Precipitation (PMP). The 100-year storm was obtained from the NOAA Atlas for Utah (Miller, et al, 1973). The PMP rainfall was obtained using the method described in NOAA's HMR 49 (U.S.Dept. Commerce, 1977). Curve numbers were chosen from tables in Van Haveren (1986) using available information on soils and vegetation cover for the watershed. A Curve Number of 70 was used to model the inflow to the tailings pond during a 100-year, 24-hour precipitation while a curve number of 85 was used for the PMP. For the hydrograph generation using the PMP, further adjustment of Curve Numbers to Antecedent Moisture Condition III was done in order to derive the Probable Maximum Flood (PMF). Times of concentration were determined using the Kirpitch formula (Miller, et al, 1974). The SCS

Type B, 6-hour storm distribution was used for the PMP. The results of these calculations are listed in Table 2.6-1.

**Table 2.6-1 Calculated Runoff Inflow into Tailings Impoundment**

| Event | Precipitation (inches) | Total Inflow (ac-ft) | Peak Inflow (cfs) |
|---|---|---|---|
| 100-Year, 24-Hour | 3.8 | 73 | 713 |
| PMP | 11.7 | 603.7 | 5,712 |

The quantities and flow rates of inflow listed in Table 2.6-1 would need to be handled by the closure design.

The water quality of the surface streams in the Mercur Canyon watershed has not been routinely monitored. However, samples were obtained for storm runoff studies conducted in 1992. Using these data, the typical water quality of the ephemeral streams in the mine area watershed are shown in Table 2.6-2.

These data indicate that the general water chemistry is characterized by high total suspended sediment and elevated levels of chlorides and sulfate. These anions are expected to be present in a disturbed mineralized area such as the Mercur drainage. The water quality is derived from contact with disturbed surfaces resulting from Barrick's activities and from areas disturbed by previous mining, concentrating, and smelting operations in the drainage basin. This water would be unsuitable for a drinking water source and is marginally suitable for sheep, cattle and wildlife.

As a consequence of the mining activities planned to occur before the tailings impoundment closure, the drainage pattern of the Mercur watershed will be permanently altered.

The Meadow Canyon watershed to the north will be blocked by the fill of Valley Fill Leach Area No.3. which has been constructed at the mouth of Meadow Canyon. This facility has an underdrain pipe that will pass most runoff events from the upstream water. For runoff events larger than this, there will be a surface bypass ditch built along both sides of the leach area.

**Table 2.6-2 Water Chemistry of Mercur Canyon Runoff at Access Road Crossing (mg/l)**

| | |
|---|---|
| Aluminum | <0.1 |
| Ammonia | <0.2 |
| Arsenic | 0.157 |
| Barium | 0.067 |
| Boron | 0.09 |
| Cadmium | <0.01 |
| Calcium | 243 |
| Chloride | 683.1 |
| Chromium | <0.01 |
| EC (1:1 leach) | 3,225 |
| Copper | 0.01 |
| Total Cyanide | 0.004 |
| WAD Cyanide | <0.002 |
| Fluoride | 0.8 |
| Gold | <0.01 |
| Iron | 0.139 |
| Lead | <0.01 |
| Magnesium | 61.9 |
| Manganese | 0.08 |
| Mercury | <0.0002 |
| Nickel | 0.05 |
| Nitrate | 2.84 |
| Phosphate | 0.10 |
| Potassium | 6.8 |
| Selenium | 0.006 |
| Silver | <0.01 |
| Sodium | 432 |
| Sulfate | 579 |
| Thallium | <0.01 |
| Zinc | 0.03 |
| pH | 8.19 |

[Average of Chemtech Reports U056141, U062490, U066202, and U066923

The natural drainage patterns from the Mercur Hill and Sacramento Hill area will be intercepted by the open pits in these locations. The balance of the runoff outside of the capture area of the pits will be rerouted over and around the overburden dumps.

The Golden Gate pit will intercept all drainage from the Meadow Canyon and Reservation Canyon watersheds and prevent this water from being discharged down the main stem of Mercur Canyon unless bypassed to UPDES outfalls which could be discharges.

## 3.0 Closure Plan Design Objectives

The closure plan for the Reservation Canyon tailings impoundment is based on design objectives which direct the type of closure which is most appropriate for the facility. These objectives are based on applicable regulatory obligations as well as the physical setting of the facility.

## 3.1 Public Health and Safety

The current tailings facility complies with applicable State and local regulations regarding public health including protection of air, surface water and ground water quality. In addition, the entire tailings facility is located within land controlled by Barrick. The current tailings facility is surrounded by a fence to exclude persons and big game. In the initial post-closure time period this fence will be maintained to enhance the potential for successful reclamation of the facility. After the release of the reclamation bond for the facility by the DOGM, this fence may not be maintained and persons may be able to gain access to the tailings basin. Such persons would potentially come in direct contact with the tailings materials or any ponded water that may accumulate on the reclaimed tailings surface. This could present a potential impact to public health. The public could also be exposed to safety risks presented by such ponded water and/or steep cut and fill slopes related to the facility. These public health and safety issues are addressed in this section.

The public health should be protected by preventing direct contact of persons with reagents or metal-bearing solids which may be potentially toxic. This would be accomplished by determining that any exposed tailings would not present a direct contact health threat, or covering such materials with enough soil to prevent direct contact. A determination of potential direct-contact health risk for the tailings was made based on comparison of the tailings solids analyses against existing environmental standards developed to review the toxicity and risk of metal-bearing wastes. One such standard is the proposed action levels for solids proposed by the U.S. Environmental Protection Agency (1990) which were developed to determine risk to persons coming in direct contact with soils or wastes at RCRA Part B facilities. The other standard is the California Total Threshold Limit Concentration (TTLC) which is a screening level test of the toxicity of a waste based on total analyses data. Neither of these sets of standards legally apply to the Mercur tailings solids but they are helpful in determining which, if any, elements in the tailings may be a concern for direct contact or ingestion by humans. The elements that these comparisons apply to are shown in Table 3.1-1.

**Table 3.1-1 Comparison of Tailings Constituents with Risk Based Standards** (mg/kg)

| Parameter | Concentration in Tailings | EPA Action Level | California TTLC |
|---|---|---|---|
| Arsenic | 1,190 | 80 | 500 |
| Barium | 3,390 | 4,000 | 10,000 |
| Cadmium | 5.4 | 40 | 100 |
| Chromium | 14.5 | 400 | 500 |
| Copper | 9.8 | NS | 2,500 |
| Cyanide | 0.4 | 3000 | NS |
| Fluoride | 4.6 | NS | 18,000 |
| Lead | 2.0 | NS | 13 |
| Mercury | 4.24 | 20 | 20 |
| Nickel | 14.1 | 2,000 | 2,000 |
| Selenium | 2.0 | NS | 100 |
| Silver | <1.0 | 200 | 500 |
| Thallium | 33.0 | 6 | 700 |
| Zinc | 39.3 | NS | 5,000 |

NS = No Standard

A review of these comparisons indicates that arsenic and possibly thallium are present in concentrations that could present a risk to humans through direct contact or ingestion.

Another potential pathway for contact with tailings constituents could result from contact with precipitation water that would collect on the reclaimed tailings surface. This water could solubilize tailings constituents. Another issue is whether runoff water discharged from the tailings impoundment following reclamation would carry sufficient quantities of soluble and suspended metals hindering compliance with UPDES effluent standards. To verify the above potential problems, a composite sample of the tailings slurry being discharged to the pond on August 27, 1993 was analyzed with the Meteoric Water Mobility Test utilized by the Nevada Division of Environmental Protection to simulate weak acid rainwater leaching of materials. The data produced by this leaching procedure are compared to water quality standards. In Nevada the material would not be considered to be a potential source of contamination as long as any of the parameters in the test leachate are in concentrations less than 10 times the applicable water standard. The results of this testing are shown in Table 3.1-2.

**Table 3.1-2 1993 Tailings Solids Meteoric Water Mobility Test Results (mg/l)**

| Parameter | Analyses | Water Standard | UPDES Discharge Limitation |
|---|---|---|---|
| Alkalinity | 42.8 | NS | |
| Aluminum | 1.66 | 50.0# | |
| Arsenic | 1.14 | 0.5 | |
| Barium | 0.176 | 10.0 | |
| Cadmium | 0.007 | 0.1 | 0.05 |
| Chloride | 33.6 | 2,500.0* | |
| Chromium | 0.033 | 0.5 | |
| Cobalt | 0.028 | 0.5# | |
| Copper | 0.006 | 10.0* | 0.30 |
| Fluoride | 3.76 | 14-24. | |
| Iron | 2.60 | 3.0* | |
| Lead | <.005 | 0.5 | 0.30 |
| Lithium | 0.007 | 25.0# | |
| Manganese | 0.032 | 0.5* | |
| Mercury | 0.0118 | 0.02 | 0.002 |
| Molybdenum | 0.028 | 0.1# | |
| Nickel | 0.036 | 2.0# | |
| Nitrate | 35.5 | 100. | |
| Selenium | 0.032 | 0.1 | |
| Silver | <.01 | 0.5 | |
| Sulfate | 814 | 2,500.0* | |
| Thallium | 0.066 | NS | |
| TDS | 1,600 | 5,000.0* | |
| Vanadium | <0.007 | 1.0# | |
| Zinc | 0.022 | 50.0* | 0.75 |

[Chemtech Lab# U098559]

Note: Water Standards are 10X National Primary Drinking Water Standard unless shown
# 10X Recommended MCLs for Irrigation Water, Ref: Nat. Academy of Sciences and Nat. Academy of Engineering, 1972
* 10X National Secondary Drinking Water Standard

The results of these analyses show only arsenic concentrations in the Meteoric Water Mobility leachate at greater than 10 times the applicable water standard. This would indicate that precipitation water in contact with the tailings solids could potentially leach arsenic out of the tailings in concentrations greater than the drinking water standard. Mercury in the test leachate was present in a concentration that was less than 10 times the drinking water standard but was in excess of the current UPDES effluent standard. This could indicate that mercury in runoff from the exposed tailings may exceed the effluent limitation.

It would appear from the above discussion, that the Barrick tailings solids could present a health hazard to members of the public who may come in direct contact with them. Runoff from exposed tailings solids may also contain elevated concentrations of certain metals. Therefore for long term protection of human health and to provide for future compliance with discharge effluent limitation, the tailings solids should be covered to isolate them from the surface environment.

The final surface topography of the tailings impoundment will be that of a broad basin sloping at about 1 to 2 percent from the top of the abutments on the west and south margins to the natural and cut slopes on the other sides of the impoundment. In addition, the constructed abutments will extend about 13 feet above the level of the tailings solids at their upstream slopes. This final topography, if not modified with a means of dewatering the basin, would have an impounding capacity and would collect precipitation and snowmelt in the northeast portion of the impoundment. Assuming no outlet is provided, average annual precipitation and snowmelt would be expected to produce a temporary pond a few feet deep but this would be expected to dry up quickly. For larger storms, the depth of water in this area could be greater. For the 100-year, 24-hour storm, assuming no discharge, the collected runoff would be about 6 feet deep in the northeast corner of the impoundment area and for the PMP, depth would be about 16 feet (see Section 4.4). This amount of water could present a safety hazard to persons entering such a pond but no more so than any other natural lake or pond.

Allowing water to accumulate in the reclaimed tailings impoundment would require continued active management of the tailings dam to assure its structural integrity and capability to retain water. Therefore, drainage of the tailings impoundment through permanent, engineered overflows is necessary. This is also required by the State Engineer's rules for abandonment of dams.

## 3.2 Protection of Ground Water Quality

Utah ground water protection regulations, and the Barrick ground water quality discharge permit require that the ground water quality protection levels specified in the permit for monitoring wells TMW-1, TMW-2, MW-8, MW-15, MW-16, MW-17, and MW-18 are maintained. The potential source for ground water pollution from the tailings facility would be leakage of pore water from the settled tailings solids through the bottom of the impoundment area. This would consist of tailings water that was originally discharged with the solids and is trapped in the solids as connate water and also any precipitation water that infiltrates into the tailings solids from the surface.

The tailings are deposited as a slurry in the impoundment and, during operations, are assumed to be saturated throughout the entire tailings deposit. The porosity of the tailings solids is likely quite variable, being controlled by particle size and depth within the impoundment. Typical porosity values for unconsolidated fine sands, silts and clay range from 30 to 55 percent (Driscoll, 1986). When the tailings facility is full with 20,500,000 cubic yards of tailings solids

$20{,}500{,}000\ yd^3$

1 acre-foot = $1{,}613.33\ yd^3$

$20{,}500{,}000 \times .45 = 9{,}225{,}000\ yd^3$

$9{,}225{,}000 \div 1{,}613.33 = 5{,}717.98$ ac-ft

$20{,}500{,}000 \times .20 = 4{,}100{,}000\ yd^3$

$4{,}100{,}000 \div 1{,}613.33 = 2{,}541.32$

used volume of tailings
instead of volume of water stored

$\frac{2{,}541}{5{,}717} = 0.44$
$= 44\%$

at a porosity of 45 percent, there will be approximately 5,718 acre-feet of tailings water stored in the pore volume of the settled tailings.

Not all of this water would be able to drain from the tailings by gravity. Part of the water would be retained in the pores by the forces of molecular attraction, adhesion and cohesion. The amount of water that can be drained from the material by gravity is called the specific yield which is expressed as percentage of the total volume of saturated material. For fine sands a representative specific yield ranges from about 10 to 30 percent; for silts and clays, the value ranges from about 1 to 30 percent (Walton, 1984). Sieve analyses indicate that 85 percent of the tailings solids are considered silt and clay sized. Therefore the amount of pore water that could be expected to drain from the tailings solids is in the range of 5 to 20 percent. Using a specific yield of 20 percent, the amount of water that could drain by gravity from the tailings solids would be 2,541 acre feet. (5,718 ACRE-FT)(0.20) = 1,144 ACRE-FT ?
? (0.05) = 286 ACRE-FT

After reclamation of the tailings surface is completed, the upper portion of the tailings would become unsaturated through evaporation and plant transpiration, however, the lower portion of the tailings would remain in a saturated condition. The contained water in this saturated portion of the tailings would remain for a long time, seeping out of the lined tailings basin at a slow rate limited by the underlying clay liner. Assuming that the clay liner has a thickness of 12 inches and a permeability of $1 \times 10^{-7}$ cm/sec, the leakage through the liner would be controlled by the overlying hydraulic head. If the solids contained in the impoundment have a permeability that is significantly greater than that of the liner itself, the leakage rate through the liner would not be reduced by the permeability of the tailings solids. However, the consolidation of the tailings solids in the bottom of the impoundment is expected to reduce their permeability to values in the range of $1 \times 10^{-7}$ cm/sec. Consequently, the effective thickness of the bottom liner would be increased which would greatly reduce the leakage rate from the bottom of the impoundment.

Using an average depth of tailings in the impoundment area of about 115 feet and the Darcy Equation (Q=KIA), the leakage rate through a 1-foot thick clay liner is calculated at approximately 86 gallons per square foot of liner per year. However, 10 feet of fully consolidated tailings over the liner decreases the calculated leakage rate to about 9 gallons per square foot per year. This is a more probable, considering the depth of tailings in the impoundment and their fine grain size. Using a tailings area of 90 acres with a leakage rate of 9 gallons per square foot per year, yields a leakage rate from the tailings impoundment of 108 acre-feet per year. At this rate, it would take at least 24 years after shutdown to drain the initial pore water from the tailings impoundment. This calculated value can only be used as a minimum value of how long the tailings facility could be expected to drain because the leakage rate would decrease over time as the amount of head decreases on the liner.

2592 ac-ft in 24 yrs

Specific yield = (0.2)(5718) = 1144 ac-ft

$\frac{1144}{108}$ = 10.6 yrs to drain pore $H_2O$ @ constant head

The initial pore water contained in the tailings solids would be expected to be chemically equivalent to that of the tailings slurry as discharged. Chemical monitoring of the tailings water has been conducted since the facility started and concentrations of water chemistry that exceed Utah Water Quality Standards both before and after startup of the INCO process were shown in Table 2.2-1. In addition to these data, water samples were obtained from three piezometers installed in the tailings during 1993, (P93-3, 4, and 5) the average concentrations of these data are shown in Table 3.2-1.

**Table 3.2-1 Water Chemistry of Tailings Pore Water** (dissolved, mg/l)

| Parameter | Tailings Water | Protection Level |
|---|---|---|
| Ammonia | 18.5 | NS |
| Arsenic | 0.979 | 0.0125 |
| Barium | 0.022 | 0.25 |
| Cadmium | <0.002 | 0.0025 |
| Calcium | 492 | NS |
| Chloride | 365 | NS |
| Chromium | <0.01 | 0.0125 |
| EC (1:1 leach) | 4,680 | NS |
| Copper | 0.019 | 0.25 |
| Total Cyanide | 15.7 | 0.05 |
| WAD Cyanide | 6.02 | NS |
| Fluoride | 1.3 | 0.6 to 2.4 |
| Iron | 3.13 | NS |
| Lead | <0.005 | 0.0125 |
| Magnesium | 3.11 | NS |
| Manganese | 0.013 | NS |
| Mercury | 0.002 | 0.0005 |
| Nickel | 1.86 | 0.0375 |
| Nitrate | 5.42 | NS |
| Nitrite | 20.6 | NS |
| Phosphorous | 0.52 | NS |
| Potassium | 18.6 | NS |
| Selenium | 0.165 | 0.0025 |
| Silver | <0.01 | 0.0125 |
| Sodium | 575 | NS |
| Sulfate | 2,093 | NS |
| Thallium | 0.997 | NS |
| TDS | 3,901 | 645 to 1,243 |
| Zinc | 0.027 | 1.25 |
| pH | 9.24 | 6.5 to 8.5 |

[Average of Chemtech Reports U091684, U091777, and U091971]

These data indicate that concentrations of arsenic, total cyanide, mercury, selenium, TDS, and pH are above the protection levels. Thus these are the elements of interest in determining the potential for deviation from protection levels resulting from leakage of the initial pore water from the tailings impoundment to the underlying ground water. As also described in Section 3.1, arsenic was leached from the tailings in the Meteoric Mobility test in concentrations more than 10x the drinking water standard which would indicate that continued leaching of arsenic into the pore water could occur after cessation of operations. MERCURY TOO?

Another potential long-term impact to ground water would be the possibility of the tailings deposit pH dropping low enough to dissolve minerals containing metals. This phenomena has been known to occur within other tailings deposits that contain significant amounts of sulfide minerals which oxidize and produce sulfuric acid. !!

However, the Mercur tailings have a significant pH buffering capacity due to the high limestone content of the ore and the fact that 2 - 10 pounds per ton of lime is added to the ground ore in the beneficiation process. This is supported by laboratory measurements of the maximum acid generation capacity of the tailings and the gross neutralization potential. The acid generation potential is due to the contained sulfide particles in the tailings which, when exposed to oxygen and water, could produce sulfuric acid. However, the acid generated is neutralized by the limestone and lime. Samples of the tailings were obtained on August 27, 1993 from the settled solids in the reclaim cell and from the slurry discharge to the tailings impoundment. The results of the acid generation and neutralization potential tests done on these samples is shown in Table 3.2-2. HAS LIME BEEN ADDED TO ORE SINCE 1983?

**Table 3.2-2 Acid Generating and Neutralization Potentials of Mercur Tailings (tons $CaCO_3$/1000 tons)**

| Sample | Acid Potential | Neutralization Potential |
|---|---|---|
| Reclaim Cell Sample #1 | 25.6 | 111 |
| Reclaim Cell Sample #2 | 26.6 | 95.1 |
| Tailings Slurry | 20.6 | 123 |

The acid generating and neutralization potential data indicate that the tailings would not produce a low-pH condition due to sulfide acidification. The acid generation capacity is relatively low because of the lack of sulfide minerals contained in the tailings. This is because the sulfide-containing ores from the Mercur operations are oxidized in an autoclave process and are not disposed of as sulfide mineral grains. The overal impact is that contained metals are not expected to become soluble in the alkaline pH of the Mercur tailings and increase their concentrations in the long-term seepage.

[illegible]

[illegible]

Previous infiltration modeling, conducted by the DWQ for design for the cap of Valley Fill Leach No.1 predicted that the annual precipitation falling at the site would be 25.34 inches and the annual runoff for a soil surface with a Curve Number of 60 would be 0.45 inches per year. Evapotranspiration from a fair plant cover was predicted to remove 23.1 inches per year. It is assumed that all of these values would be the same for the dry tailings surface if it were revegetated, or if it were covered with a topsoil cap. Using these values for precipitation, runoff and evapotranspiration, the amount of annual infiltration into the tailings would be about 1.8 inches. This infiltration value is considered to be conservative (i.e. high) because the measured, annual precipitation at the Mercur site is approximately 16 inches instead of the 25.34 inches used by the DWQ in their infiltration model. This amount of infiltration each year over the 90 acre surface of the final tailings impoundment would result in approximately 13.5 acre feet of recharge per year. This is less than the calculated seepage rate of initial pore water from the tailings and would approach the long-term (beyond 24 years) seepage rate from the facility. Thus the rate of seepage to ground water from the tailings pond leakage would be highest in the early part of the drainage history, after the facility is shut down and would gradually decrease over years to a steady state leakage rate supplied by continued annual infiltration of precipitation.

### 3.3 Protection of Surface Water Quality

The tailings impoundment and the chimney drain catchment ponds are currently considered no-discharge points under the UPDES permit UT0023884. In order to comply with the ore mining and dressing effluent limitation of 40 CFR 440.100, there can be no discharge of process water from these facilities to surface waters while these facilities are active. Once the tailings facility is undergoing reclamation, it is no longer an "active mining area" under these regulations, and the point-source effluent limitations would no longer be applicable. The EPA and DWQ storm water discharge regulations would still apply to any runoff from the tailings facility after operations are terminated. The storm water regulations include a provision that excludes from regulation those mining operations that are fully reclaimed and released from surety bonding obligations [UAC R317-8-3.8(6)(d)(3)]. Thus these regulations may not apply to the tailings facility once it is reclaimed and the bond is released by the DOGM. However, the DWQ can also impose reasonable discharge standards based on its general water quality standards or narrative criteria for receiving waters. It is unknown how stringent these discharge standards would be for the reclaimed tailings facility because there are no perennial bodies of water downstream of the facility.

The natural drainage channels of Mercur Canyon are ephemeral and currently have no surface water protection standards under State regulations. The ephemeral flow from Mercur Canyon runs into Rush Valley where it could be used for other purposes. There are no reservoirs or other developed points of diversions in Mercur Canyon downstream of the tailings facility. The most likely beneficial use for the water downstream of the facilities is for cattle or sheep that may be grazing near the natural drainage channels when they are flowing.

Barrick's current mining plans indicate that a new open pit will be excavated in the bottom of Mercur Canyon under the old Golden Gate tailings pile (Figure 2). This pit will have a storage capacity of approximately 2,890 acre-feet of water and will intercept and collect all surface runoff from upstream watersheds, including Meadow Canyon and the Reservation Canyon area. This water would be confined to the Golden Gate Pit and would not be discharged to natural stream channels off Barrick's property. Thus any discharge from the reclaimed tailings facility would be contained within the Golden Gate Pit and would not be discharged from the mining property.

Precipitation falling on the surface of the reclaimed tailings impoundment, and any precipitation inflow from uphill watersheds would be routed through the reclaimed tailings impoundment. There would be controlled discharge from the reclaimed tailings impoundment through a designed spillway system that would be added to the facility after all process solutions have been removed. The discharge from this spillway would be to Meadow Canyon upstream from the Golden Gate Pit.

The outer surfaces of the original main dam and the saddle dam have already been reseeded. These areas will be fully reclaimed by the time the mill operations are terminated. The outer faces of the levee and buttress structures will not be reclaimed at the time of closure. Runoff from the buttress above the main dam would be collected in the seepage collection system at the toe of the buttress. This will be pumped back to the tailings impoundment as long as the seepage collection pump system is still active. After the seepage collection and pump back system is no longer needed for handling seepage, runoff from the buttress above the main dam would be free to run down the rock-lined abutments of the main dam and be released at the toe of the dam. This runoff would flow to the Golden Gate Pit.

Runoff from the levee and the buttress above it would be collected in the seepage reclaim cell behind the saddle dam where the water would evaporate in place.

Immediately after mill shutdown, water collected from the interior drains within the main dam and saddle dam would be collected in the seepage collection ponds below these structures and pumped back into the seepage reclaim cell to evaporate. This would be continued until the volume of water seeping from the dams becomes small. Following any necessary permitting, a subsurface drain field would then be constructed downstream from both the main dam and the saddle dam; any continued seepage from the dams would be directed into these drain fields and allowed to infiltrate.

## 3.4 Fugitive Dust Control

Fugitive dust can result from large tailings areas when they dry out. Tailings sands and silts near the points of tailings discharge are typically loose and easily erodible by strong winds. Clayey tailings are typically less erodible because of they tend to dry into hard crusts. Strong winds over dry tailings facilities may carry dust clouds over downwind areas and carry tailings solids from the disposal facility to adjacent, off-site areas. Dunes of tailings sand may be deposited behind wind breaks both on the tailings facility and downwind of it.

The release of fugitive dust from mining facilities in Utah is regulated by the Division of Air Quality (DAQ). Fugitive dust is required to be controlled at the source. These control methods should be effective enough to maintain compliance with applicable DAQ ambient air standards.

One effective way of controlling fugitive dust, usually used during operations, is to keep the tailings wet. After closure, there will be no constant source of water to the tailings facility so the only water available to wet the surface will come from precipitation and runon from the upstream watershed. Using local precipitation records, the average annual precipitation for this site is approximately 16 inches. The annual lake evaporation rate for this site is approximately 30 inches (Barrick Pan Evaporation Data). Therefore the annual precipitation is insufficient to keep the tailings surface moist enough to prevent dry soil surface conditions during part of the year. Wind erosion and dust generation could occur at these times unless the surface were adequately stabilized.

Another permanent stabilization method that has been shown to be very effective in minimizing wind erosion is a gravel or rock cover (Vick, 1983). This treatment acts like a desert pavement in that even fine, gravel-sized material completely covering the underlying fines will prevent wind erosion. This was found to be the most effective means of dust control on a 480-acre copper tailings impoundment in southern Arizona (Bengson, 1991). In that case, spreading 1 to 2 inches of gravel-sized crushed rock was completely effective in eliminating what had been severe fugitive dust emissions. The thin cover of gravel can be applied with, heavy-duty, commercial spreader trucks typically used in agriculture. These have low-ground-pressure tires that allow the vehicles to travel over dried tailings.

Chemical dust control methods using various binding agents such as lignosulfate, polymers, resins, and asphalt emulsions, have been shown to be ineffective in permanently stabilizing dried tailings surfaces. However, these have merit as interim dust control measures that can be applied as necessary on a dry tailings facility until permanent control measures become effective.

Wind breaks of planted trees and shrubs, or snow fences have also been shown to be effective in reducing off-site wind transport of sand and silt from dried tailings (Bengson, 1991). These reduce wind velocities on the lee side of the windbreaks and cause deposition of windborne sand and silt. The deposited material forms sand dunes along the wind breaks. Windbreaks are effective at reducing wind erosion and transportation off the site of sand and silt but are not as effective in preventing removal of finer material which results in dust clouds. Temporary windbreaks such as snow fences are helpful as interim stabilization of a tailings surface, or to reduce sand-blasting of emerging vegetation. Shrubs and trees provide long-term wind erosion control, but even these may not be permanent because fire or other natural causes may remove them.

Perennial vegetation that consists primarily of drought and fire resistant grass species is considered to be a permanent and effective cover to prevent wind erosion. The vegetation breaks the wind acting directly on the ground surface by producing a zone of still air in the critical few inches immediately above the ground. To control dust during the establishment of this vegetative cover, and prevent sand-blasting of emerging vegetation, various types of mulch, including a thin rock mulch, can be added to cover the bare tailings surface, (Caldwell, 1990). Overstory vegetative cover of trees and shrubs can also reduce wind erosion but do not cover as high a percentage of tailings area as grass and are not considered to be as important for control of wind erosion.

The final closure treatment of the Mercur tailings impoundment surface will need to provide for interim dust control until the final cover can be established. The final cover will also need to provide for permanent dust control.

## 3.5 Structural Stability

The Reservation Canyon tailings facility, when finally closed, will be a permanent topographic feature containing over 20 million cubic yards of tailings at a final tailings elevation of approximately 7347 feet. The tailings surface will then be approximately 334 feet above the original ground surface under the centerline of the original main dam and approximately 174 feet above the ground level under the centerline of the levee structure. It is necessary that this topographic feature be structurally stable in the long term.

There are three main objectives of structural stability for the reclaimed tailings facility. The first is the long-term slope stability of the impounding dam. This must be able to permanently hold the tailings solids and contained tailings water within those solids. The stability of the dam must be satisfactory under both static and earthquake conditions.

The second stability objective is that the dam must be able to resist overtopping from any future water accumulation in the impoundment area. There are no spillways constructed in the dam because the tailings facility is operated as a no-discharge facility. The final configuration of the closed tailings facility must ensure that any foreseeable climatic and hydrologic condition at the site will not result in water overtopping the dam. This could result in severe erosion of the dam and impair its ability to contain the tailings.

The third stability objective is that whatever design is adopted for the final cover of the tailings solids must be able to accommodate future settlement of the tailings solids themselves. Tailings solids typically have lower relative densities than natural soils because of the angular grain shape of tailings particles and the fact that they usually undergo little consolidation during operations. Relative density is the ratio of the in-place unit weight over the maximum compacted unit weight. Because of the low relative densities and saturated conditions of tailings at the time of facility closure, the tailings solids can undergo significant consolidation and surface settlement as they dry out. This is less of an issue for sands and silts deposited subaerially but can be quite significant for slimes which are typically deposited in a subaqueous condition.

### 3.5.1 Mass Stability of Dam

The mass stability of the final tailings dam has been analyzed for both seepage impacts and slope stability (Physical Resource Engineering, 1993a).

7,360 IS TOP OF BUTTRESS (PG 9)

The seepage analyses assumed operating conditions for the tailings facility with pooled tailings water being present in the impoundment area about 500 feet away from the dam. The buttress was assumed to be constructed to a maximum height of 7,330 feet. The computer modeling indicated that the rock buttress would remain unsaturated and that the water percolating into the buttress would drain from the buttress toe into the seepage collection ditch located there. The main dam was also shown to be in an unsaturated condition downstream of the clay core and drain structure. Based on actual seepage flows from the structures to date, the anticipated seepage from the buttress at closure should be 7,200 gallons per day and 1,700 gallons per day through the levee. This drainage rate could decrease if the rock used to construct these features becomes clogged with tailings fines. Based on experience to date, flow from the drainage system of the original dam at the time of closure is expected to be approximately 4,300 gallons per day. In summary, the tailings dam is anticipated to remain in a safe, unsaturated condition during operations and this condition will only improve after operations cease and tailings water is not being discharged to the impoundment.

The slope stability analyses addressed potential failure of the dam under both static and seismic conditions. The seismic conditions assumed that a magnitude 7.0 earthquake could occur along the Mercur Fault about 4 miles west of the facility. The estimated return period for this event is 5,000 years. This would be a greater earthquake acceleration than a predicted magnitude 7.5 earthquake event along the Wasatch Fault because the later is located over 25 miles away.

The minimum factor of safety against rotational slope failure of the original dam and the maximum height buttress was 1.7 for the static case and 1.34 for the dynamic case (0.1g). The dam exhibited a factor of safety greater than 1.0 up to a seismic acceleration of about 0.24g. A magnitude 7.0 earthquake is estimated to produce a seismic acceleration of about 0.5g at the facility site. This would be expected induce a slope failure on the dam that would have displacements of about 2 feet but would not involve the contained tailings (Physical Resource Engineering, 1990). As the tailings become drained over time after facility closure, the pore water pressures in the tailings and the buttress are expected to decrease and the factor of safety against slope failure should increase over time.

The potential for liquefaction of the tailings solids was also checked and it was concluded that the average grain size of the tailings and strength data from friction cone tests indicated that the Mercur tailings are not very vulnerable to liquefaction (Physical Resource Engineering, 1990).

NOT VERY BAD (?) HOW BAD? QUANTIFY?

11.7 INCHES, 6HR

### 3.5.2 Flooding of Impoundment

The Probable Maximum Precipitation (PMP) is the appropriate storm for long-term closure plans of facilities because it represents the maximum amount of precipitation that could ever be expected to fall in one storm, regardless of return period.

The present diversion ditch will divert most of the upland runoff to Meadow Canyon only as long as it remains open. Because of its size and construction, it may remain open for a significant period of time. However, future geomorphic processes such as soil creep and slope failures may destroy the diversion ditch. Therefore, it has been assumed to be non-functional for the hydrology design of the tailings facility closure.

The average annual precipitation contribution to the impoundment, is estimated to be 16 inches. The annual evaporation rate for the facility location is estimated to be about 30 inches per year. Thus, even ignoring infiltration into the tailings, there should be no permanent accumulation of surface water in the impoundment due to the average annual precipitation.

The tailings are discharged to the impoundment along the inside face of the buttress which results in a slope on the tailings solids from the dam toward the back of the impoundment. This slope is approximately 1 to 2 percent which will result in a maximum tailings solids elevation of about 7347 feet against the buttress and 7332 feet at the east margin of the impoundment. Therefore, the majority of the water holding capacity in the impoundment area will be in the northeastern portion of the facility.

In compliance with State Engineer regulations, the facility will be fitted with engineered surface drainage structures to prevent any significant impounding conditions within the reclaimed tailings basin.

WHAT ARE THESE STRUCTURES? ⇒ SPILLWAY CHANNEL EMERGENCY BREACH OK

### 3.5.3 Settlement of Tailings Surface

The tailings solids are deposited under both subaerial and subaqueous conditions. The sand fraction of the tailings is deposited on a typically subaerial beach whereas the silt and clay fractions are typically deposited in a subaqueous environment. The in-place, dry unit weight of the sands on the beach is about 94 pounds per cubic foot (PCF) and this is not expected to increase as the tailings desiccate after termination of operations. The surficial silts and clays have dry unit weights of about 85 PCF and are anticipated to consolidate as they desiccate.

One form of consolidation is achieved through drainage of pore water achieving a closer grain packing while the sediments remain saturated. This is a gradual process that is controlled by the rate contained water can be drained from the system and the overburden loads. This consolidation will be faster with the sandy tailings that are located nearest the drainage systems in the tailings dam than in the less permeable silts located further out into the tailings impoundment. The slowest sediments to drain will be the clayey tailings because they are the furthest from the drainage systems and have the least permeability. The total amount of consolidation is typically less for sandy materials than silty materials because the initial void space in the silty materials is greater. The total amount of consolidation in clays is greatest because they have the largest percentage of initial void space.

The second consolidation process is desiccation shrinkage of clayey materials. This process occurs from the surface downward in a clayey tailings once it is exposed to the air and sunlight. Saturated clayey sediments shrink both vertically and laterally as they desiccate. The vertical shrinkage is displayed as surface settlement and the lateral shrinkage is displayed as cracking. This shrinkage can vary from 10 to 30 percent. The cracks that result from desiccation of thick clay deposits can vary from 2 to 6 inches in width and can extend downward over 6 feet. The desiccation cracks typically do not remain open and are filled with sand carried over the tailings surface by the wind.

One potential result of consolidation of the tailings is the settlement of the buttress which is supported by the tailings. The total settlement of the maximum height buttress was predicted to range from about 2.8 to 9.4 feet (Physical Resource Engineering, 1990). These values could be higher as the tailings beneath the buttress drain and consolidate. Settlement is monitored during operations, and fill material is added to the buttress as required to maintain the required freeboard. This will be done up to the time of tailings facility closure.

⇒ AT FINAL RELEASE? OR AT CESSATION OF MILL OPERATIONS?

## 3.6 Post-Mining Land Use

The intended land use for the tailings facility following its closure would be wildlife habitat.

# 4.0 Proposed Conceptual Closure Plan

The components of the proposed conceptual closure plan have been selected to meet the design objectives discussed in Section 3.0. The closure plan is generally designed to protect public health and safety, provide for the long-term stability of the facility, minimize future impacts to the environment, and comply with regulatory requirements.

## 4.1 Dewatering

Following cessation of mill operations, the remaining pool of water will be allowed to completely evaporate. If necessary, the remaining water can be evaporated more rapidly by pumping it from the low point in the tailings basin through a pipe to connect with the peripheral discharge piping. The water would then be discharged through the existing piping and spread out over the entire tailings basin. This larger wetted area would accelerate the overall evaporation of the remaining water volume.

## 4.2 Removal of Equipment

Following the dewatering operations, the pumps, piping and other equipment that were no longer necessary would be rinsed to remove any remaining processing solutions and be removed from the tailings facility. These would be disposed of off-site or in the Mercur landfill.

BARRICK'S LANDFILL?

## 4.3 Cap Design

The cap to be applied to the top of the tailings would result in removing the tailings solids from the surface environment and reduce infiltration into the tailings. A topsoil cap of about 12 inches would completely cover the tailings solids. This would eliminate the risk of direct contact with humans and would eliminate transport of soluble tailings constituents into surface runoff. The topsoil would also provide a suitable growth medium for a cover of perennial plants. The vegetation would protect the topsoil cap from erosion and would provide evapotranspiration to reduce the net infiltration of precipitation into the underlying tailings.

Is 12" sufficient depth for plant growth

Previous studies of cap design conducted by the DWQ for the Mercur Valley Fill No.1 closure plan have indicated that surface runoff and evapotranspiration account for the removal of over 90 percent of all annual precipitation that falls on the cap. Installing a clay cap and lateral drainage layer under the topsoil layer results in diversion of less than 2 percent of the annual precipitation, the rest being able to leak through the clay layer and into the underlying waste. Thus the benefit of adding a layered cap on the tailings with a clay layer and lateral drainage layer is very small when compared with the additional cost and difficulty in constructing such a cap. - true

It would be very difficult to construct a layered cap on the tailings because this would require placing and compacting native clay as the lowest layer of the cap. This would not be possible on the tailings because they are underconsolidated and would not support compaction equipment. It would not be possible to compact the clay layer without first placing a thick underlayer to support the compaction equipment working on the clay even if the compaction is achieved with haulage equipment only. Experience has shown that dry tailings will typically support bulldozers spreading topsoil or other uncompacted covers as long as the dozers work on the topsoil and not the tailings themselves. The equipment used to haul the cover material must work on roadway fills placed on the tailings that are 3 to 5 feet thick and can support the wheel loads of the haul equipment. This is expected to be the case for the Mercur tailings.

3-5 FT THICK ROADWAY FILLS NEEDED FOR EQUIP. TO PLACE TOPSOIL.

Placing a 12-inch thick topsoil cover over the tailings would meet the design objectives of removing the tailings solids from the surface environment and reducing the infiltration rate.

## 4.4 Surface Drainage

During the period when the tailings are being dewatered, the tailings pond would remain as a no-discharge facility with all water being contained within the dam. After the surface of the tailings are dried, and no process water remains on the surface of the tailings basin, the tailings impoundment would be fitted with a spillway and controlled breach in compliance with State Engineer requirements. Construction of these outlets would also be delayed for at least 2 years following shutdown of the tailings facility to allow the surface of the tailings solids to consolidate and settle. In this way, the final grading of the outlet works is more likely to join the long-term surface elevation of the tailings solids

SPILLWAY 2 YRS AFTER DE-WATERED

Using projected topographic data for the top of the final tailings surface, the depth/storage relationship for the reservoir was generated. This is shown in Table 4.4-1.

**Table 4.4-1 Depth/Storage Relationship of Final Tailings Reservoir**

| Depth (feet) | Storage (Acre-feet) |
|---|---|
| 0 | 0.0 |
| 3 | 26.8 |
| 8 | 143.7 |
| 13 | 397.0 |
| 15 | 553.0 |

This storage capacity information indicates that, assuming no discharge from the impoundment, the 100-year, 24-hour inflow to the basin could be stored in a pool with a maximum depth of about 6 feet in the northeast corner of the impoundment. This would be easily stored in the northeast portion of the impoundment at least 400 feet away from the dam. The inflow from the PMP, if not allowed to discharge, would be stored in a pool about 16 feet deep measured in the northeast corner of the impoundment. It would be expected to cover the entire impoundment and touch the base of the dam. During the post-reclamation period for the tailings facility, it has been assumed that the drainage diversion currently present in Reservation Canyon uphill from the tailings impoundment would cease to be effective and all runoff from the upland watershed would enter the tailings basin. – not a good idea

In order to provide for complete drainage of the tailings basin, a spillway would be cut into solid rock across the pass between Reservation and Meadow Canyons located to the north of the tailings pond (Figure 6). This would be trapezoidal in cross section with a bottom width of at least 12 feet, depth of at least 10 feet, side slopes of 2.5h:1v and a channel slope of about 0.005. The conceptual spillway would have a nominal inlet elevation of 7330, a discharge elevation of 7327, and would be approximately 600 feet long. This channel would have the capacity to pass the design peak flow at a velocity of less than 10 fps. This would allow complete drainage of the impoundment with minimal temporary storage during large storm events. The outlet of the channel would be onto solid rock on the slope of Meadow Canyon or rip rap of sufficient size to prevent damage to the spillway during the PMF flow event. Rip rap would also be placed at the inlet to the spillway as required to prevent erosion of the tailings.

conflicts w/ Table 4.4-1

For small storm events there would be minimal backwater storage in the tailings impoundment. During the peak inflow from the 100-year, 24-hour precipitation event (713 cfs) there would be less than 30 acre-feet of storage in the tailings impoundment which would attain a maximum depth in the northeast corner of the impoundment of about 2 feet. During the peak inflow from the PMP (5,712 cfs) there would be less than 290 acre-feet of storage in the tailings impoundment which would attain a depth of about 10 feet. At this depth, the maximum water level would not contact the base of the dam. In both of these cases, all of the water in the temporary storage would drain out of the impoundment within 24 hours of the storm event.

The inlet elevation of the spillway would be set to about 2 feet below the lowest elevation of the settled tailings in the northeast corner of the tailings impoundment to provide a slope of at least 0.1 percent for drainage from the tailings impoundment. A channel would be excavated through the tailings solids from the northeast corner of the impoundment to the spillway inlet. This channel would have a bottom width of at least 30 feet and side slopes of 4h:1v. It would be lined with a soil cap like the rest of the tailings but the top of the soil in the channel would be covered after seeding with a plastic erosion prevention mat such as Miramat by Mirafi or equivalent. This material would ensure that the channel would be immediately protected from erosion while the permanent vegetation cover is established.

riprap instead of erosion mat?

In addition to the spillway outlet described above, if required by the State Engineer, another engineered breach could be installed in the dam (Figure 6). The purpose of this breach would be to provide another means of discharge from the tailings pond in the unlikely event that the main spillway would become plugged. This would be a trapezoidal channel excavated through the rock fill of the buttress on the south side of the tailings impoundment down to the elevation of the tailings solids. This channel would be carried over the south buttress to join a channel excavated to the east of the reclaim cell leading to Manning Canyon. The channel would have a bottom width of at least 12 feet and would be lined with rip rap sized to resist erosion for the peak discharge through this channel during the PMF event, assuming the spillway is not functioning. The inlet elevation to the breach would be higher than the maximum temporary storage stage of water in the impoundment during normal flow of the PMF through the spillway. Thus, the breach would only experience flow during the rare emergency condition of a PMF event should the main spillway become plugged.

## 4.5 Vegetation

The surface of the tailings solids would be revegetated directly to establish a dense cover of vegetation which would minimize wind and water erosion while the upper portion of the tailings is dewatered prior to capping with topsoil. This initial revegetation would also provide a mat of dry vegetation under the soil cap which is expected to help in spreading the soil over the soft underlying tailings. Finally, the initial vegetation cover would accelerate the dewatering of the upper portion of the tailings by the added evapo-transpiration affect which would tend to draw the moisture from the tailings in the root zone.

Analyses of the tailings solids obtained from two pits in the surface of the tailings impoundment in August, 1993 are presented in Table 4.5-1. Reviewing these analyses with the total chemistry data presented previously in Table 2.2-2 indicate that the tailings solids are suitable for use as a growth medium except for insufficient phosphorous and moderately elevated sulfates. Deficiencies in nutrients would be initially overcome with applying ammomium phosphate fertilizer at a rate of 160 pounds per acre.

**Table 4.5-1 Analyses of Tailings Solids for Growth Medium** (mg/kg)

| Parameter | Pit 1 | Pit 2 |
|---|---|---|
| Sodium Adsorption Ratio | 2.22 | 1.17 |
| Calcium (sol.) | 955 | 2,950 |
| Potassium (sol.) | 24.1 | 33.5 |
| Magnesium (sol.) | 14.3 | 16.6 |
| Sodium (sol.) | 252 | 231 |
| $CaCO_3$ (sol.) | 31.1 | 28.3 |
| Total Kjeldahl Nitrogen | 700 | 724 |

The tailings solids will initially be very wet when the pool of water is just being removed from the impoundment. During this time, the portion of the tailings solids that are exposed would be too wet for dryland vegetation species. However, it is desirable to cover the tailings with a fast growing crop of vegetation to limit erosion of the surface, begin adding organic material, and accelerate drying of the tailings surface through evapotranspiration. This first seeding would be broadcast planted in concentric strips as necessary following the emerging solids as the water initially evaporates. The recommended species are shown in Table 4.5-2.

To be planted directly into tailings

**Table 4.5-2 First Interim Seeding Mixture** (lbs/acre p.l.s.)

| Common Name | Scientific Name | Seeding Rate |
|---|---|---|
| Common Reed | Phragmites australis | 4.0 |
| Reed Canarygrass | Phalaris arundinacea | 8.0 |
| Meadow Foxtail | Alopecurus pratensis | 3.0 |
| Redtop | Agrostis stolonifera | 2.0 |
| Thickspike wheatgrass | Elymus lanceolatus | 4.0 |
| Meadow fescue | Festuca pratensis | 4.0 |
| Alsike clover | Trifolium hybridum | 2.0 |
| Strawberry clover | Trifolium fragiferum | 4.0 |
| Total lbs/acre | | 31.0* |

* Reduce the rate by 1/2 if drill seeded

As the tailings solids dry out, these wetland species would die out but not before they add significant organic matter and fiber to the tailings surface. This would augment it as a seedbed and give more support to low ground pressure equipment traveling over the tailings surface.

After the tailings dry out, a second crop of cereal rye would be drill seeded through the previous seeding. This would be a hardier dryland species which would further dewater the tailings during the dry growing season.

After the tailings have been sufficiently dewatered and consolidated, at least one full year, to support the construction of the soil cap topsoil would be spread over the dry tailings surface to a thickness of approximately 12 inches. After the topsoil is applied and before seeding, it would be scarified and amended with 2 tons per acre of green alfalfa hay mulch and 140 pounds per acre of diammonium phosphate fertilizer. The permanent seed mix shown in Table 4.5-3 would then be planted with a seed drill.

**Table 4.5-3 Final Seeding Mixture** (lbs/acre p.l.s.)

| Common Name | Scientific Name | Seeding Rate |
|---|---|---|
| Intermediate wheatgrass | Elymus hispidus | 2.0 |
| Smooth Brome | Bromus inermis | 2.0 |
| Western wheatgrass | Elymus smithii | 2.0 |
| Orchard grass | Dactylis glomerata | 1.0 |
| Russian Wildrye | Elymus junceus | 1.0 |
| Indian Ricegrass | Stipa hymenoides | 2.0 |
| Chickpea milkvetch | Astragalus cicer | 1.0 |
| Utah sweetvetch | Hedysarum boreale utahensis | 1.0 |
| Yellow sweet clover | Melilotus officinalis | 1.0 |
| Alfalfa | Medicago sativa | 2.0 |
| Pacific Aster | Aster chilensis | 0.5 |
| Palmer penstomen | Penstemon palmeri | 1.0 |
| Blue flax | Linum lewisii | 1.0 |
| Fourwing saltbrush | Atriplex canescens | 2.0 |
| Rubber rabbitbrush | Chrysothamnus nauseosus | 0.25 |
| Little rabbitbrush | Chrysothamnus viscidiflorus | 0.25 |
| Big Sagebrush | Artemisia tridentata | 0.25 |
| Total lbs/acre | | 20.25* |

* Double rate if broadcast seeded

## 4.6 Monitoring

Following completion of the closure plan for the tailings, monitoring would continue in compliance with the DOGM, DWQ, and DWR permit requirements.

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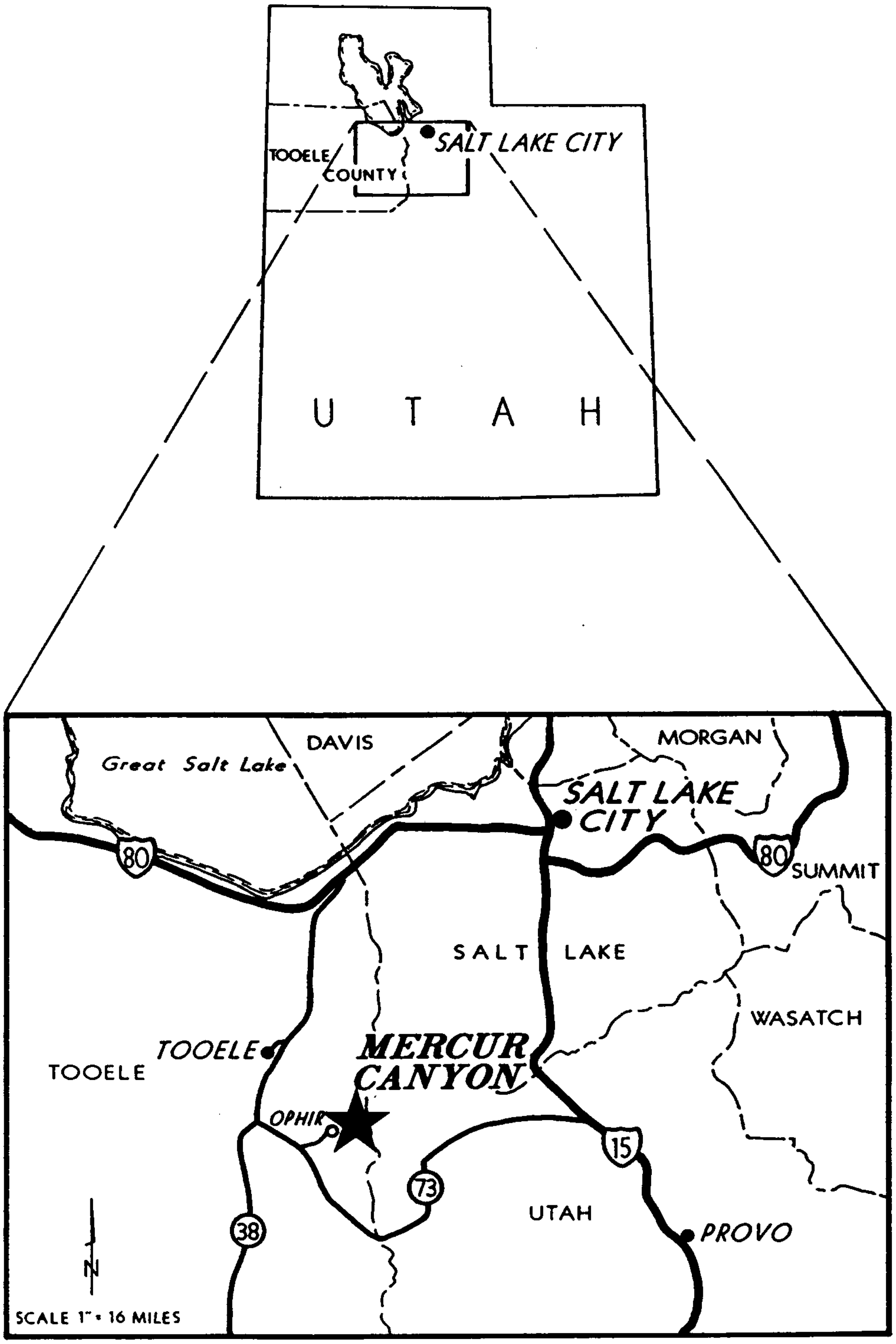
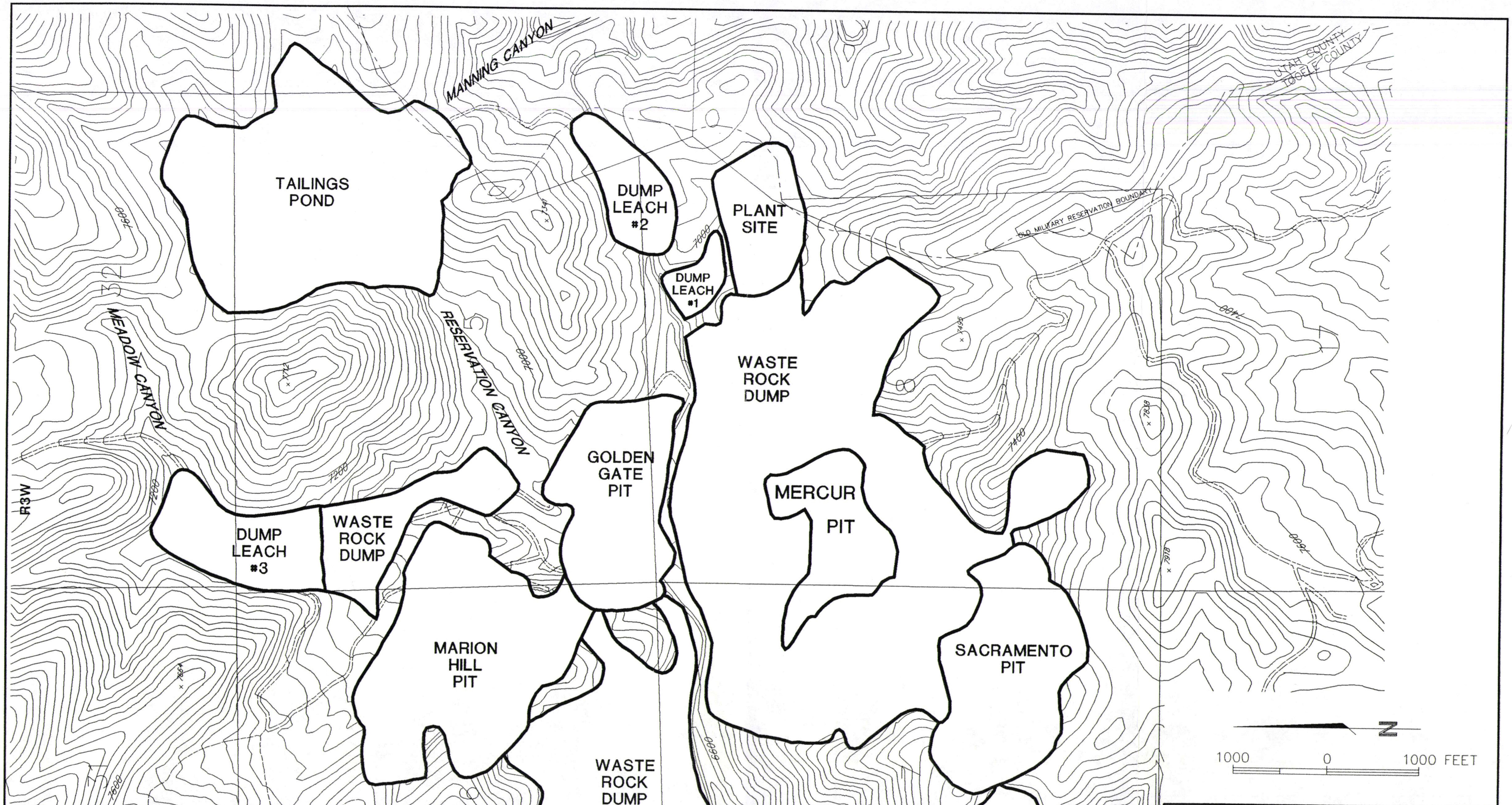



FIGURE 1 LOCATION MAP

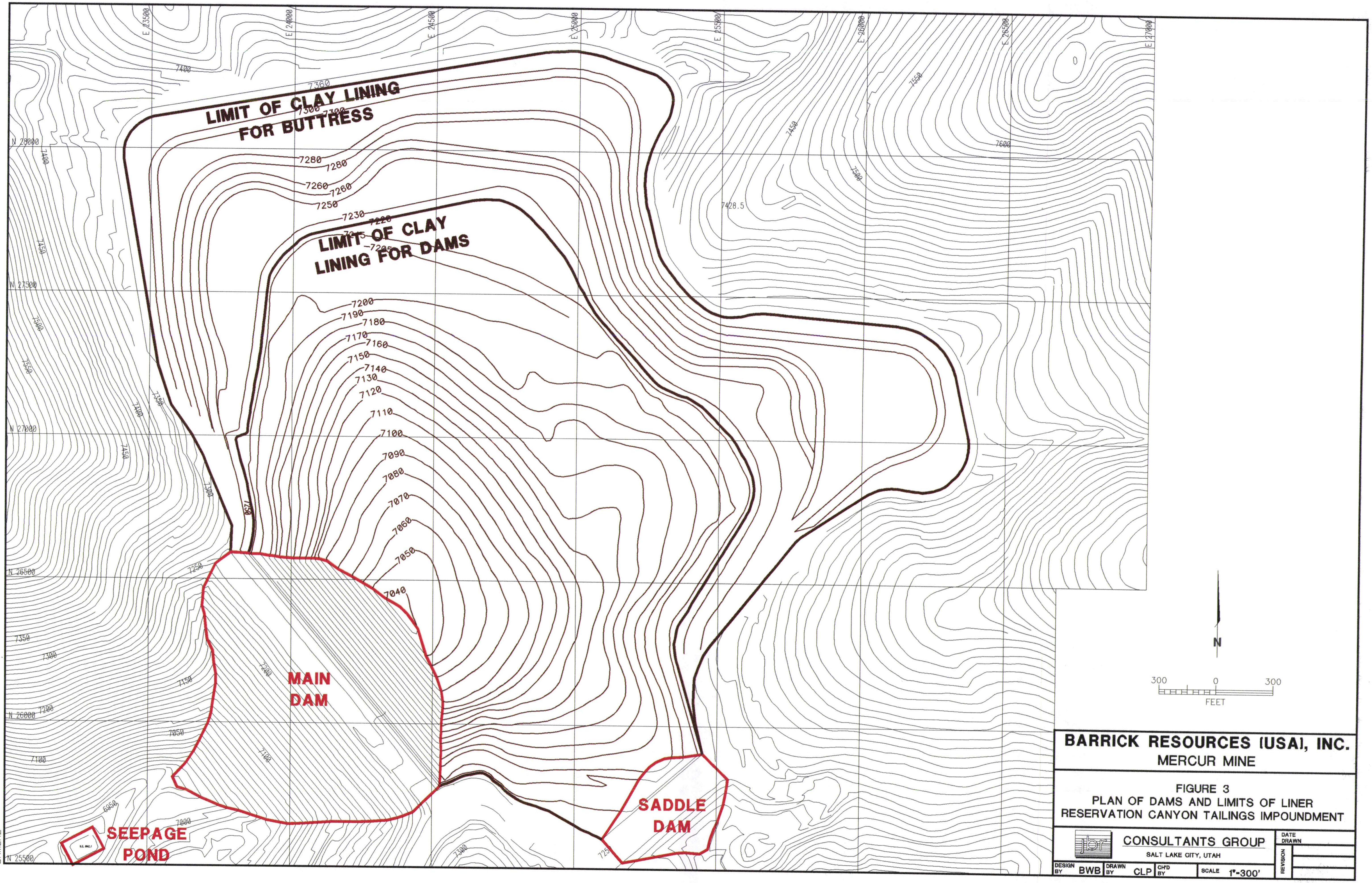
JBR CONSULTANTS GROUP




**BARRICK RESOURCES (USA), INC.**
MERCUR MINE

FIGURE 2
PROPERTY LAYOUT MAP

| | | | | | |
|---|---|---|---|---|---|
| JBR CONSULTANTS GROUP<br>SALT LAKE CITY, UTAH | | | | DATE DRAWN | 11/23/21 |
| DESIGN BY BWB | DRAWN BY CLP | CHK'D BY | SCALE 1"=1000' | REVISION | |


LIMIT OF CLAY LINING
FOR BUTTRESS
LIMIT OF CLAY
LINING FOR DAMS
MAIN
DAM
SADDLE
DAM
SEEPAGE
POND
N
300 0 300
FEET
BARRICK RESOURCES [USA], INC.
MERCUR MINE
FIGURE 3
PLAN OF DAMS AND LIMITS OF LINER
RESERVATION CANYON TAILINGS IMPOUNDMENT
CONSULTANTS GROUP
SALT LAKE CITY, UTAH
DESIGN BY BWB
DRAWN BY CLP
CH'D BY
SCALE 1"=300'
DATE DRAWN
REVISION
BKMER2

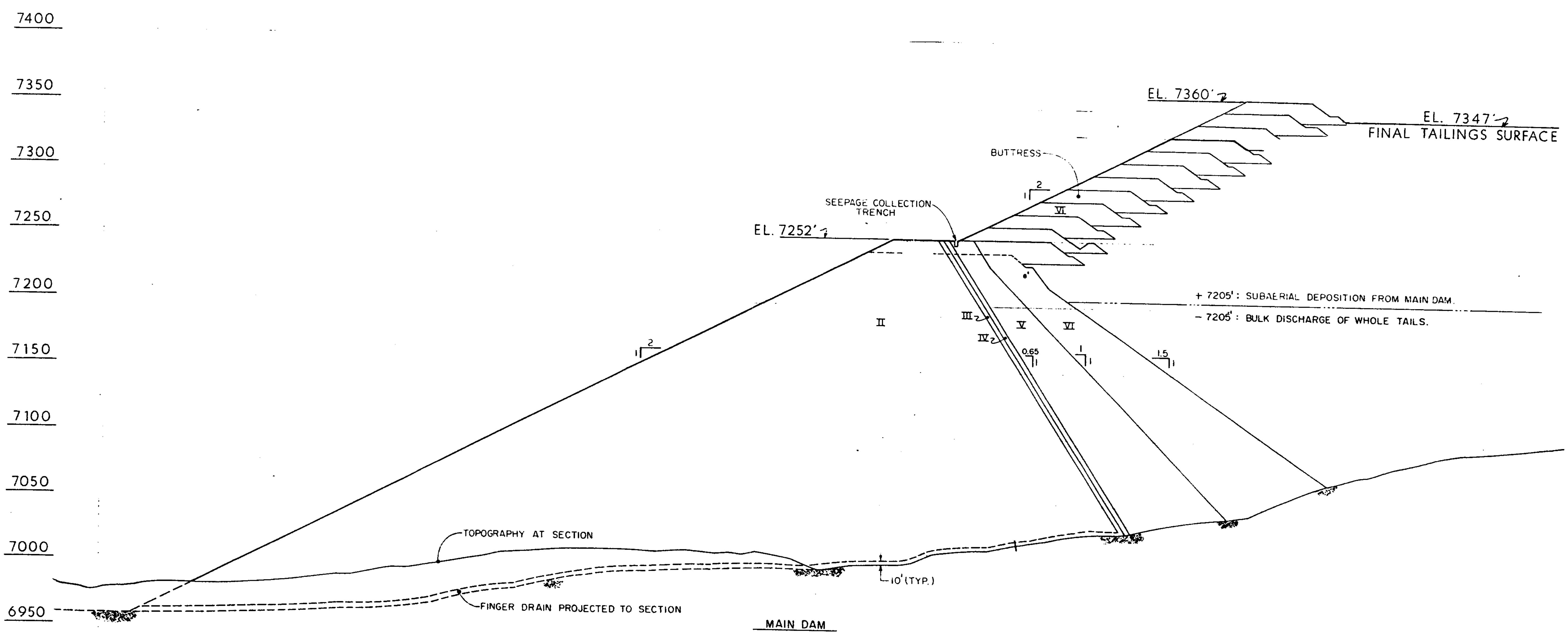



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FIGURE 4
CROSS SECTION THROUGH MAIN DAM
AND BUTTRESS SHOWING FINAL ELEVATIONS

CONSULTANTS GROUP
SALT LAKE CITY, UTAH

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DESIGN BY | BWB | DRAWN BY | CLP | CH'D BY | | SCALE | 1"=80' |

DATE DRAWN 11/23/21

REVISION

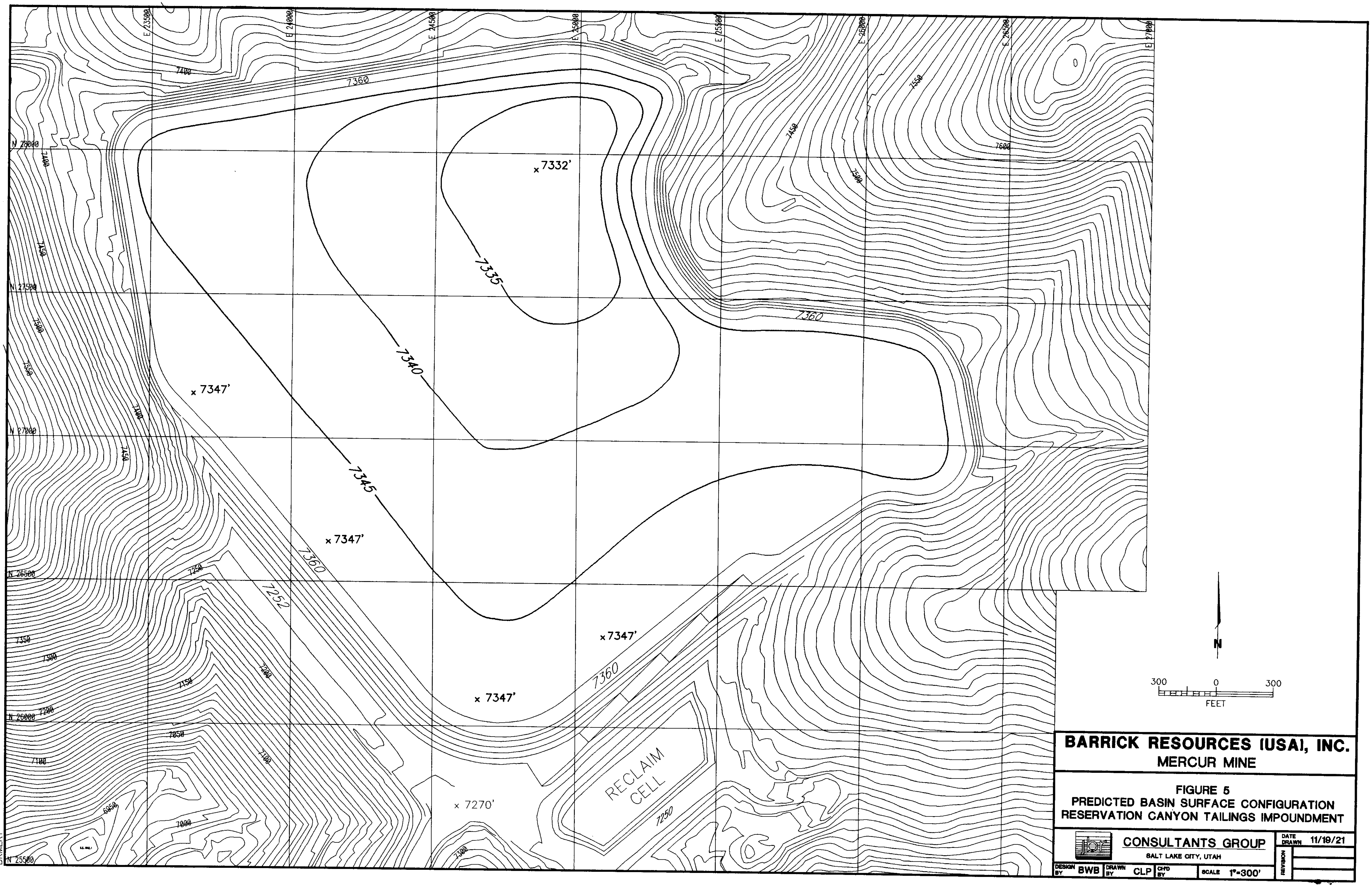


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FIGURE 5
PREDICTED BASIN SURFACE CONFIGURATION
RESERVATION CANYON TAILINGS IMPOUNDMENT

CONSULTANTS GROUP
SALT LAKE CITY, UTAH

| DESIGN BY | BWB | DRAWN BY | CLP | CHECKED BY | | SCALE | 1"=300' | DATE DRAWN | 11/19/21 |
|---|---|---|---|---|---|---|---|---|---|

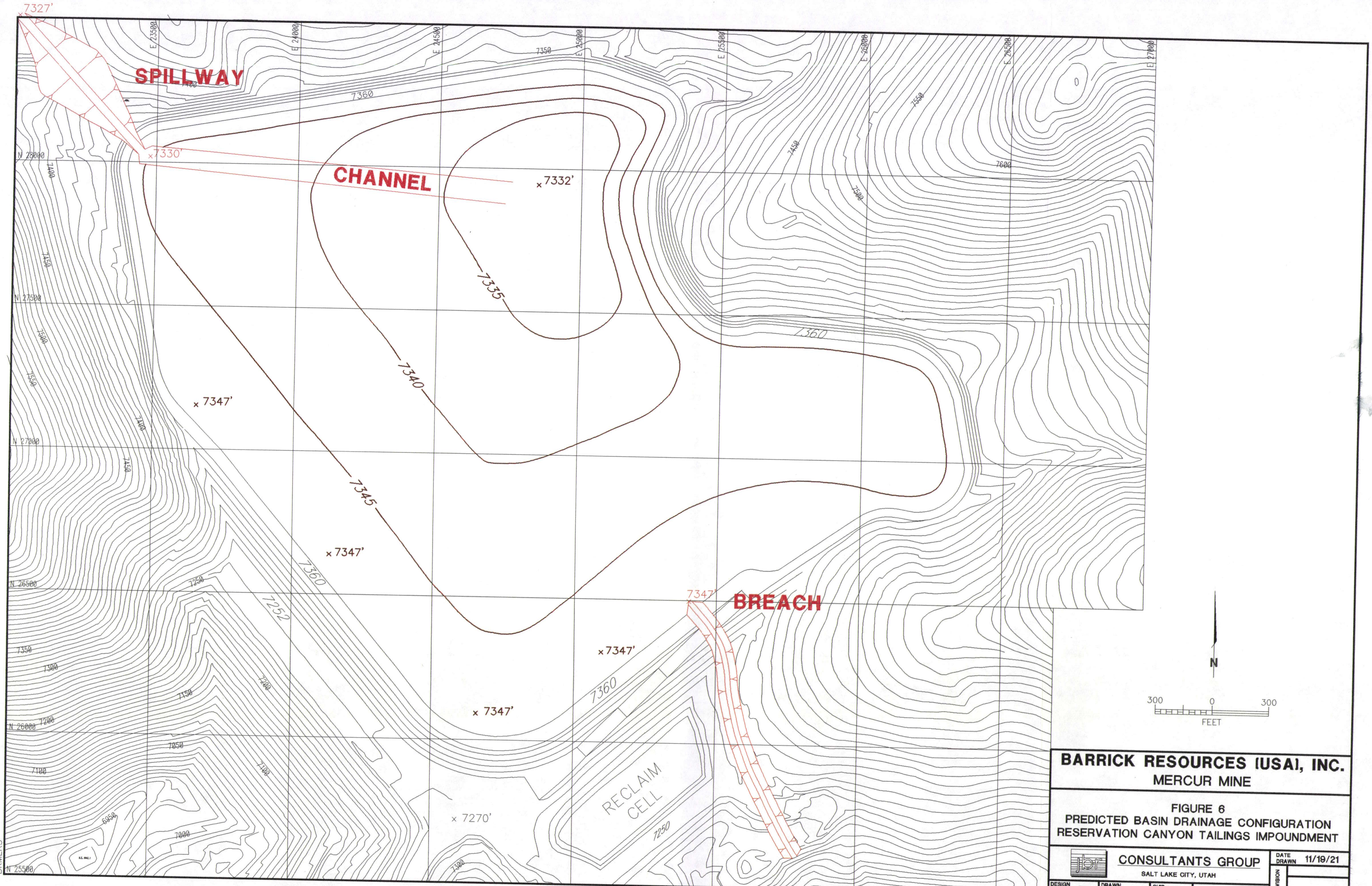


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FIGURE 6
PREDICTED BASIN DRAINAGE CONFIGURATION
RESERVATION CANYON TAILINGS IMPOUNDMENT

JBR CONSULTANTS GROUP
SALT LAKE CITY, UTAH

| DESIGN BY | DRAWN BY | CHD BY | SCALE | DATE DRAWN |
|---|---|---|---|---|
| BWE | CLP | | 1"=300' | 11/19/21 |

REVISION

BKMER3